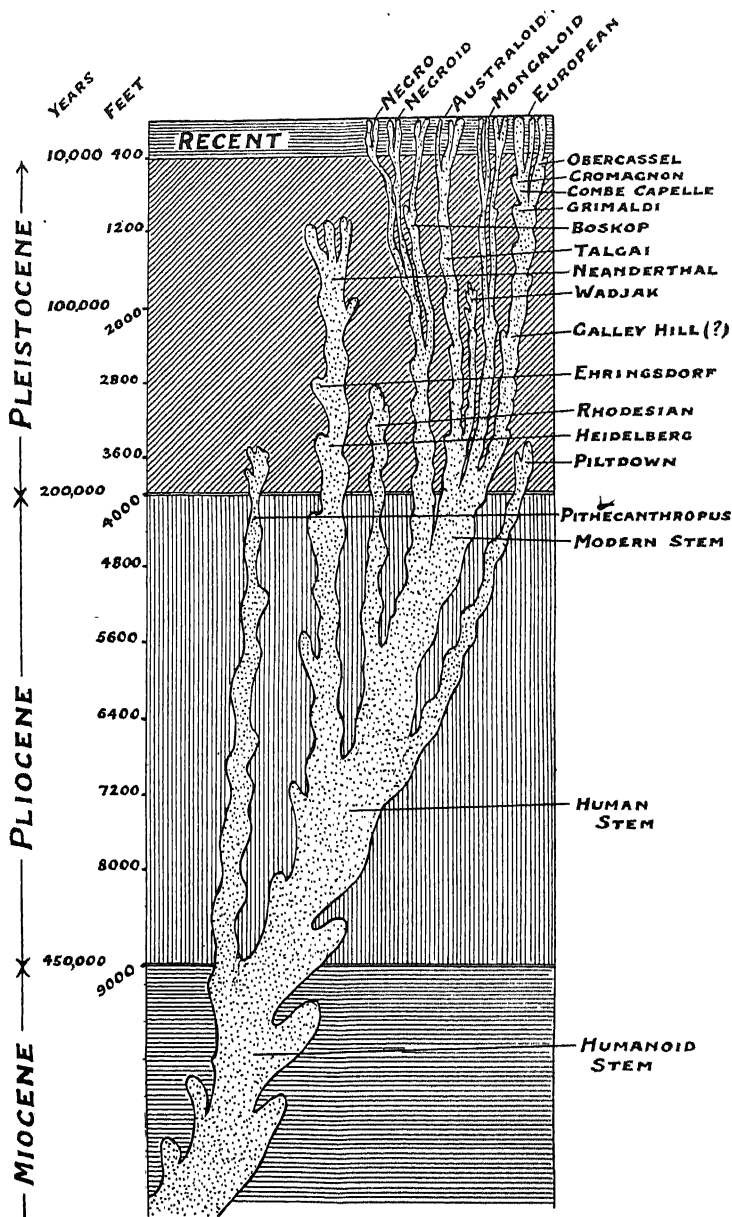# THE ANTIQUITY OF MAN

Genealogical tree indicating the ancestry of living and extinct races of mankind. On the left are given estimated depths of the more recent geological deposits and of the time occupied by their accumulation.

THE

ANTIQUITY

OF

MAN

BY

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THE ANTIQUITY OF MAN

CHAPTER XX

RHODESIAN MAN

In the course of our survey, described in the previous chapter, we had to cross the Zambesi above the Victoria Falls, where we duly noted the high-level gravels containing the stone implements of ancient man. It is from this point we are to renew our search of ancient man in Africa, for we cannot suppose that the big-brained Boskop people we have been inspecting are as old as these high-level gravels; there must have been a much more primitive type of man in this part of Africa in still earlier days, and it is for such a type we are now to look. Before us, beyond the Zambesi, lies Northern Rhodesia, whither we are bound, while behind us we leave the rich country of *King Solomon's Mines*—Southern Rhodesia—over which Sir Rider Haggard has cast the spell of romance. We are to see in this chapter that a great cave in Northern Rhodesia has things to tell us that are stranger than fiction. From it we are to obtain a clearer picture of early man than ever we had before. We are to find that the wild dreams of the Darwinists have a solid basis in fact.

The reader will see from the sketch map (p. 357) that the railway, after crossing the Zambesi on its way to the Belgian Congo, passes Broken Hill some 300 miles from our starting-point. The country hereabouts is flat and often marshy; the streams which issue from it ultimately pour their waters into northern tributaries of the Zambesi. At the beginning of the present century, before the railway had advanced this far into the black man's

country, a limestone kopje, some 50 feet in height, rose from a swampy flat. Early adventurers, approaching the kopje from the south, found at its foot—at its south-western base—the mouth of a vast cave. This cave became famous for two things—the almost diamond-like brilliance of the stalactites which hung from its vaulted roof, and the stalagmites which rose to meet them from the floor; and for its fossil bones. Bones cumbered the floor in immense quantities; almost all of them broken and splintered. Thousands of elephant, hippo-potamus, rhinoceros, zebra, and antelope had contributed to this vast mausoleum; the lion, leopard, and hyæna had added their quota. As the traveller lighted his torch to explore its recesses, he brought about his ears bats and owls, which made their home in the darkness of the cave and no doubt added their skeletons to the bone strata of the floor when they died, to say nothing of the remains of voles and other small rodents ejected from the stomachs of the owls. With torch in hand the traveller saw that the cave ran in an eastward direction under the kopje, the floor having a downward slope. Farther on, progress became impossible, for the accumu-lation of bones reached the roof. Everywhere there were abundant signs of the cave having been the abode of man. Its stone implements were of the kind still fashioned by Bushmen; the paintings and decorations found in the cave were done in his style. In the country round the cave the Bushman is no longer seen; long ago his place was taken by the Barotse, a Bantu-speaking negro people, akin to the Matabele and Zulu.

The conditions which we have just noted in our pre-liminary survey of the Broken Hill cave brings to mind the great cave of Malta—Ghar Dalam. We must con-clude that the vast accumulation of bones in the floors of both of them are, for the greater part, the scraps and refuse which the ancient cave-dwellers flung aside in the course of their meals. In this prodigious and ancient refuse heap at Broken Hill we are to search for the records of early man.

We should never have discovered the secrets which lay hidden in the depths of the Broken Hill cave had not the business man come to our aid. In Europe it is the business man—the cement manufacturer, the builder, roadmaker, and miner—who has supplied students of man's evolution with all their original " documents." And so it proved at Broken Hill. The limestone of this district, of which the kopje is but an outcrop, is rich in ores of lead, zinc, and the rarer metal, vanadium. In 1905 the Broken Hill Exploration Company began to work the limestone for its metals, quarrying not only into the side of the kopje, but also deep into the rock beneath. In 1907 mining operations had advanced far enough to expose a large part of the cave in section, and by good fortune a geologist, Mr F. P. Mennell, happened to come that way and made a record of what was being revealed.[1] It is well to note here what he saw, and what he inferred, because geologists, after human remains have been discovered in a deposit, always find reasons for reducing their antiquity. Mr Mennell formed the opinion that the " hundreds of tons of bones " which had accumulated in, and completely filled, the deeper part of the cave, entailed the passage of " a long period of time." Everywhere through the bone deposits occurred rude implements of quartz and chert, knives, scrapers, and grooved scrapers, resembling the tools still fashioned by Bushmen. Some bones had cuts on them, made before they had become fossilised. An examination of the cave deposits made him realise that they had " accumulated during alternate occupations of the original cavern by animals and human beings, with intervening periods when the cave was untenanted owing probably to flooding with water." Mr Mennell was convinced that the evidence to be gleaned at Broken Hill in 1907 " affords the strongest presumption of the great antiquity of man in this part of the world."

The bone contents of the cave ran into many hundreds

[1] F. P. Mennell, F.G.S., and E. C. Chubb, " An African Occurrence of Fossil Mammalia Associated with Stone Implements," *Geol. Mag.*, 1907, vol. xliv. p. 443.

of tons, and as the bones had absorbed the metals, they went with the limestone to the smelting furnace. The Directors of the Broken Hill Company, although their aims were primarily commercial, had also the larger outlook which values knowledge as well as dividends. Samples of the fossil bones were sent from the cave to the Rhodesian Museum in Bulawayo, and to the Natural History Museum, South Kensington. Whole bones were rare, and exact identification of the animals they represented difficult. Mr Mennell found fossil bones of an extinct species of rhinoceros, but the conclusion reached by the late Dr Charles Andrews and by Mr E. C. Chubb was, that the animals entombed in the cave were almost identical with those which still flourish in Africa south of the Equator. We have no reason to believe that the animals and plants of Africa have ever been subjected to such violent climatic changes as fell upon those of Europe during the Pleistocene period. There may have been long periods of drought and periods of rain, but the conditions in tropical and semi-tropical Africa have been such as to conserve its ancient fauna. For this reason, we must not let the idea run away with us that the fossil bones of this cave are recent, because they belong to species of animals which are still alive. Man of the Chellean culture lived in Europe with just such animals for company as are found in the cave at Broken Hill. Nor must we lay stress on the fact, that these bones, fossil though they be, have yet an unexpected freshness in their texture. Zinc salts, such as abound in the limestone of Broken Hill, were selected by anatomists long ago as ingredients of the solutions in which delicate animal tissues are preserved.

Late in the summer of 1921 the miners were approaching that part of the quarry which enclosed the deepest recesses of the cave. They were then working 140 feet below the summit of the kopje and 90 feet below the level of the surrounding land. By this time it was apparent that the original cave had been shaped as set out in fig. 134, where a vertical section of the kopje

and underlying rock [1] is looked at from the south side. From this plan it will be seen that the cave, as it penetrated beneath the kopje, sloped downward, so that 150 feet from the mouth its floor had descended 30 feet below ground level, at which point the descent became steep, the ultimate recesses of the cave being reached 60 feet deeper still. Beyond the bend, the cave was choke-full of bones soaked in a composite mass of cave earth rich in mineral ore, for the water level rose as high as the sharp bend in the floor—30 feet below ground level. The bones were thus embedded in a matrix rich
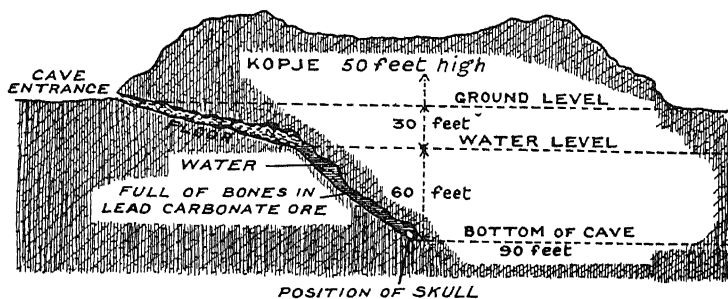
FIG. 134.—A diagrammatic section of the kopje and underlying limestone rock at Broken Hill, showing the length and lie of the original cave. The section is represented as looked at from the south side.

in preservative salts. It is very likely that in ancient times the level of the subsoil water stood much lower, making it possible for the earliest adventurers to reach the utmost depths of the cave dry footed. But it is also tempting to suppose that the depths of the cave, beyond the sharp bend, even if this deep part were full of water, would serve as a convenient place for ancient man to dump his refuse or to dispose of his slain foes. On the other hand, the utmost recesses of the cave, when approachable, may have served the original cave-dweller as a family tomb. For, as we shall see, the deepest part of the cave did serve as the last resting-place of the dead, but whether from accident or design we cannot tell.

[1] Mr Mennell describes the limestone as mixed with a schistose rock and quartz. Magnesia also occurs.

It came about, late in the summer of 1921, that Mr W. E. Barren, a mining engineer from New Zealand, was making his round in the mine or quarry, and came across a black labourer thrusting his pick amongst fossil bones which a successful charge had blasted from the deepmost recesses of the ancient cave. Mr Barren intervened, and thus saved the skull of Rhodesian man—the most complete and important document that has yet lain on the anthropologist's table—from being broken into fragments and sent to the melting-pot. Looking round, Mr Barren found other human bones in the confused mass of fossilised remains which lay exposed. He found the complete tibia of a left leg, the upper and lower ends of a left thigh bone, a sacrum (the key bone of a human pelvis), and part of the upper jaw, which belonged to an individual other than him who owned the skull; for in it the upper jaw was complete. Parts of at least two persons were found—perhaps more than two.

News of the discovery soon became bruited abroad. Early in October 1921, the *Sunday Times* of Johannesburg devoted an article to it, and gave a drawing taken of the skull while it was still masked by a coating of mineralised earth. Crude as this drawing was, it proved sufficient, when it arrived in England, to excite the curiosity of anatomists. Early in November the skull and other fossil bones reached London in charge of Mr R. Macartney, manager of the Broken Hill mine; the directors of the company presented them to the Natural History Museum, South Kensington, where they passed into the charge of Sir Arthur Smith Woodward. Even before reaching the seclusion of South Kensington, Rhodesian man became famous; the daily and illustrated newspapers took notice of him.[1] Sir Arthur Smith Woodward gave a preliminary account of him.[2] An excellent cast of the brain cavity of the skull was made by Mr F. O. Barlow, which was studied

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[1] See *Times*, 8th, 9th, 10th, and 11th November 1921; *Illustrated London News*, 19th November 1921.

[2] *Nature*, 17th November 1921. See also *Science Progress*, 1922, vol. xvi. p. 574.

and briefly described by Professor G. Elliot Smith.[1] Professor Eugene Dubois[2] came from Holland, and Professor G. L. Sera[3] from Italy, to see the skull; and published accounts of it. At the time this chapter was written (August 1924) no adequate official account of Rhodesian man had been published, but Sir Arthur Smith Woodward very kindly permitted the writer to make a close examination of all the Rhodesian bones, the account given here being founded on what was observed then, and on casts of the skull which were withheld from British anatomists for fully two years after the moulds had been completed.

What was the stature of the Rhodesian man and how did he carry his body? To help us in answering these questions we have at our disposal (1) a complete tibia of the left leg, (2) a thigh bone of the same limb, but we cannot tell its exact length for the middle part of its shaft is missing, (3) a sacrum—the key-bone of the pelvic arch. A comparison of the form and proportion of these three bones leaves no doubt in my mind that they and the skull were part of the same individual, and that this individual was a man—a tall and strong man, perfectly erect in his carriage. As Australian aborigines are universally regarded as the most primitive of living races of mankind, and as they have more points of resemblance to Rhodesian man than any other living race, I chose the skeleton of a native man, 5 feet 6½ inches (1685 mm.) in height, and compared the Rhodesian bones with his. The Rhodesian tibia was slightly longer than the Australian; the total length of the first was 418 mm., of the second 413 mm.; if we take the length between their upper and lower articular surfaces, the measurement for the Rhodesian is 402 mm., for the Australian 400 mm. We might, therefore, conclude that Rhodesian man was

[1] *British Med. Journ.*, 1922, i. p. 197.

[2] " On the Cranial Form of *Homo Neanderthalensis* and of *Pithecanthropus erectus*, determined by Mechanical Factors," *Konin. Akad. van Wetensch. te Amsterdam*, 1921, vol. xxiv. p. 1.

[3] *Revista di Biologia*, 1922, vol. iv. p. 2.

about the same stature as the Australian—about 5 feet 7 inches. In reality he was at least 3 inches more—about 5 feet 10 inches (1776 mm.). This result we arrive at by following several lines of evidence. The tibia of the Australian aborigine is relatively long when compared with his femur ; in the skeleton just mentioned the length of the tibia was 87 per cent. of the length of the femur, whereas amongst Europeans it varies between 80 per cent. and 84 per cent. ; in Neanderthal man the tibia was relatively short. If we estimate the height of the Rhodesian man from the length of tibia, as we may do, by using Pearson's formula, we obtain a stature of 5 feet 10 inches. We reach the same conclusion when we take the Rhodesian femur into consideration. The articular surfaces of the lower fragment fit those of the upper end of the Rhodesian tibia ; they certainly formed parts of the same knee-joint. When we seek for thigh bones having the same dimensions and proportions as the Rhodesian fragments, we find them in Europeans with a stature of 5 feet 10 inches or 5 feet 11 inches, and with thigh bones which measure about 510 mm. in length. In the skeleton of the Australian, used for comparison, the length (or height) of the femur was 477 mm., whereas in the Rhodesian man it must have been about 500 or 510 mm. Hence we infer that the tibial part of his lower limb had not the great relative length seen in negroes and Australian aborigines, but was relatively short, as in Neanderthal man, and also as in Mongolian races and in many Europeans.

In the thigh and leg bones of Neanderthal man we have noted points of resemblance to the corresponding bones of the gorilla (p. 221), but there are no such simian traits in those of Rhodesian man. In type, although not in detail, the bones of his lower limbs are altogether modern. Among human races, as amongst the breeds of horses and dogs, we find some which tend to a heavy, massive form of body and limb—the Shire horse, the mastiff, the brawny European ; we see others assume a lighter make of body and limb—the greyhound, the blood-horse, the

Australian aborigine ; pygmy or dwarf forms also occur amongst horses, dogs, and men. All of these forms we can explain if we accept the theory that growth is regulated by hormones.[1] The Rhodesian man was of the heavy cart-horse type, the shafts of his long bones were strong, and their articular extremities in ample proportion. The diameter of the head of his thigh bone was 49 mm., the width of its lower end 88 mm. ; the width of the upper end of his tibia 87 mm., the width of its lower end 48 mm. There was no front-to-back flattening of the upper part of the shaft of his femur ; in this region the width is 32 mm., the front-to-back diameter 27 mm. Towards the middle of the shaft the corresponding measurements are 28 mm., 29·5 mm. Nor was there side-to-side flattening of the tibia more than is usual in modern man. In its upper third the front-to-back thickness of the tibial shaft is 39 mm., its side-to-side measurement 26 mm. ; at the middle of the shaft the corresponding measurements are 33 mm., 24·5 mm.

The shafts of the femur and tibia were particularly straight—more so than is seen in any race now living—being in this character the opposite of ape-like. When the Rhodesian tibia is placed on a table, with its posterior surface downwards, the highest point in the concavity or bend of the shaft rises only 16 mm. above the surface of the table. There are just the same degrees of twist or torsion in the shaft of his femur and tibia as occur in the generality of living peoples. From all of these circumstances we infer that Rhodesian man held himself just as erect as we do, and that his gait was the same as ours. Further, he was a hefty fellow, weighing 12 stones (76 kilos) at least. It is difficult to assess his age ; his front teeth are greatly worn ; the sutures of his skull can be

[1] Those who wish for further information on this theory may consult the following papers by the author : *Lancet*, 15th April 1911 ; *Journ. Anat. and Physiol.*, 1910, vol. xliv. p. 251 ; *ibid.*, 1913, vol. xlvii. p. 189 ; *Johns Hopkins Hosp. Bull.*, 1922, vol. xxxiii. pp. 155, 195 ; *Lancet*, 1919, vol. ii. p. 553 ; *Nature* (Supplement), 18th August 1923 ; *British Assoc. Rep.* (Bournemouth), 1919, p. 275.

clearly traced.   He was in full manhood—probably about thirty-five or forty years of age.

A close comparison of the Rhodesian sacrum with those of the gorilla and the Australian aborigine and other races brings out no point which is really noteworthy. Its narrowness and its straightness are primitive features, but the extent and form of its articular surfaces are altogether human—those of a robust man.   There is nothing about it the least suggestive of the female sex.

If we had found merely the limb bones or sacrum of Rhodesian man we should have placed him, just as we place the Cromagnon and Boskop peoples, amongst the extinct races of modern man—*Homo sapiens*.   When we come to examine his skull—particularly that part which contained his brain—we see that such is not his place; he is far more primitive—more ape-like, more gorilline— than any of modern man's variants, living or extinct. He deserves, as he has received, the rank of a separate species.   But it is a species of the utmost interest, for it reveals for the first time the ancestral type of modern races.

In fig. 135, the brain-containing part of the Rhodesian skull is viewed in profile and placed within the standard frame [1] used throughout this book for purposes of comparison.   We see at once that the length of the skull far exceeds the standard; it measures 210 mm. in place of 190 mm.   We note, however, that this great length is due, not to size of brain, but to bony outgrowths from the forehead and occiput, which we shall see are connected with size of jaw and strength of neck.   In a modern European, with the same length of brain cavity as the Rhodesian man, namely, 171 mm., we expect the skull to measure 186 mm.   Of its total length the skull of the modern European is made up thus : 92 per cent. is brain space, and 8 per cent. is bony wall, whereas in the Rhodesian skull the brain space amounts to 81·4 per cent., while the bony part makes up 19·6 per cent.   In the larger Neanderthal skulls the bony element forms 16 per cent. of their total length, while in the skulls of male gorillas

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[1] For orientation of the skull and use of the standard frame, see p. 582.

this element rises to 27 per cent.[1] Thus we see that in proportion of bone and brain Rhodesian man is more gorilline than any of the known fossil types of man, not excepting the Java man. And yet the thickness of the vault of Rhodesian man is only a little more than is
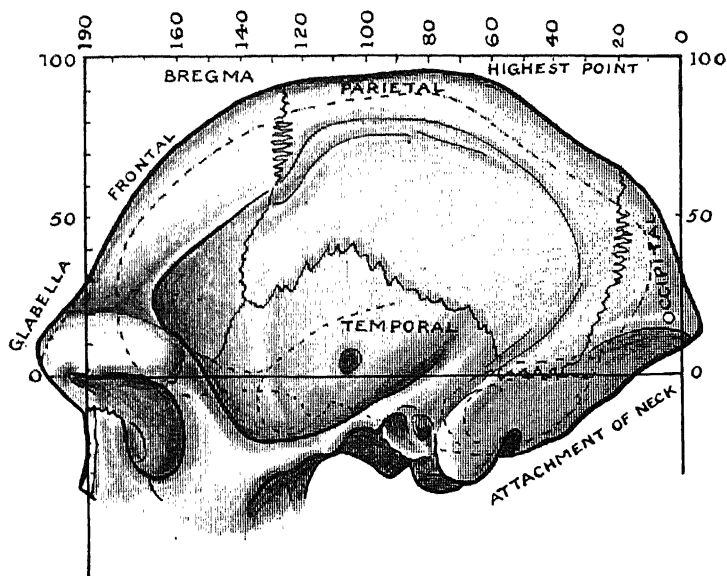
FIG. 135.—The cranial or brain-containing part of the Rhodesian skull, viewed in profile and placed upon a standard frame.

common in modern skulls,[2] whereas in most Neanderthal skulls the thickness of the vault reaches 10 mm.

[1] The proportion between brain length and skull length has been recently investigated by Herr Weinert (*Zeitschrift für Ethnologie*, 1922, vol. liv. p. 199). He finds that the proportion of brain length to skull length in the following apes and men is : Gorilla, 75 per cent. ; chimpanzee, 81 per cent. ; Neanderthal man, 86 per cent. ; Australian aborigines, 88·5 per cent. ; Europeans, 92 per cent. ; Pithecanthropus, 84 per cent. ; all of which correspond with the figures given in the first edition of this book.

[2] This is founded on a statement made by Sir Arthur Smith Woodward. When an exact drawing of the endocranial cast is placed within an equally exact drawing of the skull, it is seen (fig. 137) that the thickness of the Rhodesian vault approaches that of Neanderthal man.

As may be seen from fig. 135, the highest point of the vault of the Rhodesian skull falls 5 mm. short of the 100-mm. level; it rises only 107 mm. above the ear passages, 8 mm. less than is usual in the skulls of Englishmen. The skull is low-roofed, especially when we consider its great length. The vault, too, when viewed in profile, as in fig. 135, has features which are noteworthy. Its highest point—the point which reaches nearest to the upper horizontal line—the 100-mm. line—lies behind the bregma, fully one-third of the way along the parietal bone; there is in this region a distinct elevation, with a sinking-in, both in front and behind. This elevated area lies immediately over that part of the brain which controls the movements of the lower limbs and which has to do with the upright posture. We shall see that the brain cast shows a corresponding elevation or outgrowth. It will also be seen that the " highest point " rises only 2 mm. above the region of the *bregma* (fig. 135). Now, when the skulls of anthropoid apes are oriented on the same plane as that adopted in fig. 135, the highest point lies in the region of the bregma. Even in the skull of the Java man, this is also the case. The rise of the parietal area of the vault is a human character. In the Rhodesian skull we see this evolutionary change well under way.

In fig. 136A, a view is given of the vault of the Rhodesian skull as seen from above, at right angles to the view we have been studying. Beside it is placed the corresponding aspect of the Boskop skull. Both far exceed the length of the standard frame, but while the vault of the Boskop skull covers brain space all the way, a large part of the frontal region in the Rhodesian skull is made up of bone— the great eyebrow ridges which have taken on the shape seen in the foreheads of the gorilla, chimpanzee, and Neanderthal man—the form to which the name *torus supraorbitalis* is given. In width both skulls exceed the side bounds of the frame—set 140 mm. apart—the Rhodesian by 5 mm., the Boskop by 15 mm. In both skulls the bony side walls make up about 6 per cent. of the

total width—a proportion which is usual in modern skulls. The total length of the Rhodesian skull is 210 mm.; its greatest width 145 mm.; the width is 69 per cent. of the length. The *cephalic index* is 69, but if by this term we seek to express the form of the brain-containing part of the skull, then it is clear that we must deduct the bony outgrowths at the front and back, to gain a just com-
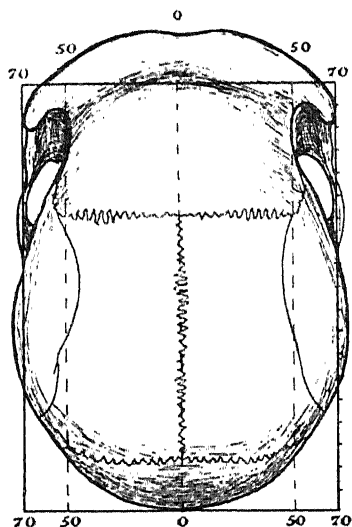
FIG. 136A.—The vault of the Rhodesian skull, view from above, vertical to the plane shown in fig. 135.
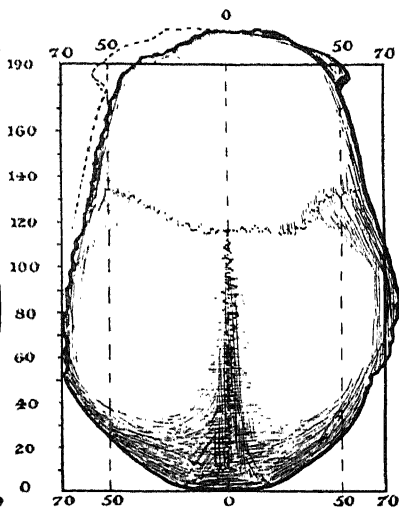
FIG. 136B.—A similar view of the Boskop skull for comparison.

parison with the skull form of modern man. When this reduction is made, the length of the brain-containing part of the Rhodesian skull falls to 186 mm. and its cephalic index rises to 78, bringing it from the ultra long-headed group towards the upper range of the medium-headed class.

What was the size of the brain of Rhodesian man? Sir Arthur Smith Woodward estimates it to have been 1280 c.c.; Professor Eugene Dubois, 1400 c.c. The cast of the brain cavity, supplied to the Museum of the Roya College of Surgeons, displaces 1305 c.c. of water. If we

apply the Lee-Pearson formula [1] for estimating cranial capacity to the reduced diameter just mentioned—length 186 mm., width 145 mm., auricular height 107 mm.—an estimate of 1370 c.c. is obtained. The Rhodesian man had a brain which in bulk was at least 1300 c.c., but even this sum leaves his race in the small-brained group of humanity, for anthropologists agree that races in which the brain volume of the average male is under 1350 c.c. are to be regarded as " small-brained," while those in which the male average is 1450 c.c. or over are to be assigned to the highest or " large-brained " class; the " medium-brained " group includes those which range from 1350 to 1449 c.c. In volume the brain of Rhodesian man was small and primitive, but certainly human—more human than the external appearance of the skull leads one to expect.

The low stage in the evolution of the human brain as seen in the Rhodesian man, lies not in its small volume but in the form and relative size of its convolutionary areas or lobes. It is true that endocranial casts taken from the skulls of aboriginal Australians show deficiencies of brain development of the Rhodesian kind, but none of them to the profound degree which we see in the cast of this ancient skull. To give the reader a broad conception of the stage of brain development reached by Rhodesian man we shall compare his brain cast (or endocranial cast) with that of Sir Thomas Browne, an Englishman endowed with mental gifts of a high order but by no means a superman. The volume of his brain was fully 200 c.c. greater than that of Rhodesian man. In fig. 137, the Rhodesian skull is represented as laid open from front to back with its endocranial cast placed within it to represent the brain. In fig. 138, the same thing has been done for the skull of Sir Thomas Browne. In both, the basi-cranial axis is exposed. We have already drawn attention to the downward bending of the front or ethmoidal part of the basi-cranial axis in the Boskop skull (p. 368), but in the Rhodesian skull the ethmoidal part (fig. 137, B) is

[1] See p. 596.

not bent down; it runs parallel to the plane of orientation. It behaves exactly in the same way in the skull of Sir Thomas Browne (fig. 138), for in him the unbending is particularly great for a modern skull. This feature of Sir Thomas' skull must be linked with the backward slope of his low forehead. The babes of ape and man are born with upright foreheads; a slanting position comes on, if
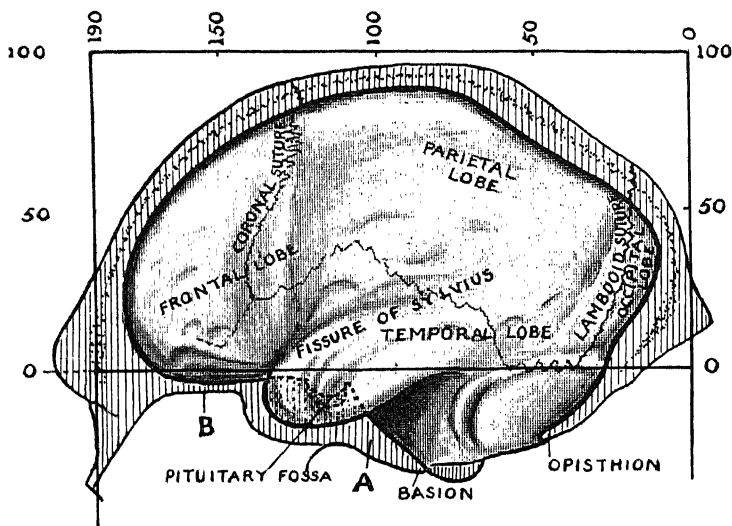
FIG. 137.—The Rhodesian skull laid open and its endocranial cast placed within it to represent the brain.

A. Basilar part of the basi-cranial axis.
B. The ethmoidal part of basi-cranial axis.

it comes at all, in childhood and youth, and depends on the unbending of the basi-cranial axis (see fig. 80). A retreating forehead is truly a simian trait, although it may cover a brain of high mentality. It will be noted, however, that the basilar part of the basi-cranial axis is a much thicker and stronger plate of bone in Rhodesian man than in Sir Thomas Browne.

A glance at fig. 137 shows that there is a marked sinking-in of the Rhodesian " brain " cast—in its hinder and upper part—between the elevation which marks the convolutions which have to do with feeling and motion

in the trunk and lower limbs, and the occipital lobe which
is primarily concerned with sight and perception.   In Sir
Thomas Browne this area of the parietal lobe, which is
concerned with the discrimination of differences in time
and space, has become enormously developed and filled
out.   So, too, when we compare the temporal lobes
which are primarily connected with hearing and the
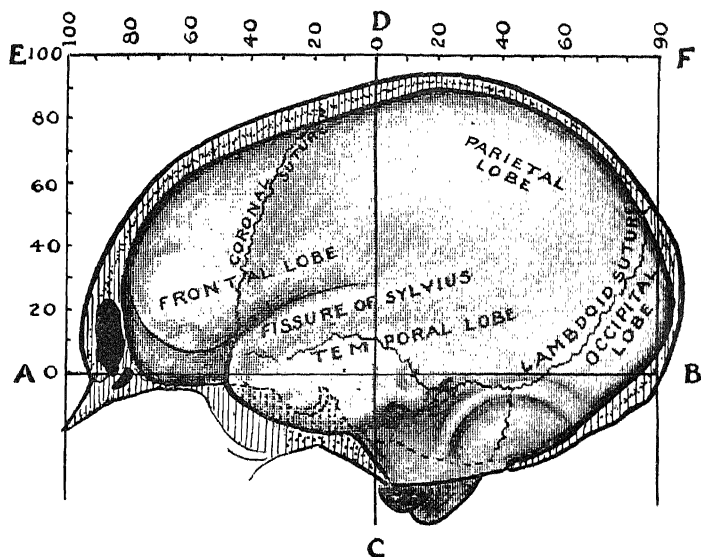
FIG. 138.—The skull of Sir Thomas Browne represented as if cut open
     from front to back, with the endocranial cast placed in position
     within it.

discrimination of sounds, we see that there is an enormous
difference in size and convolutionary development between
them.   The temporal lobe of the modern brain surpasses
that of the ancient at all points.   It is evident, too, that
the front part or stem of the fissure of Sylvius (fig. 138)
is more open—more simian—in the Rhodesian brain than
in that of Sir Thomas Browne.   But as regards the
frontal lobe, particularly its more anterior convolutions
in which the human brain so much excels that of the ape,
the differences between the brain casts we are now com-
paring are less marked.   It is rather in the hinder areas of

this lobe, the areas in front of those which have to do with the acquisition of new kinds of movement, that the Rhodesian brain falls so much short of the modern brain. It is when we take account of the great differences which separate the brain of a man so primitive as the Rhodesian from that of a modern man, particularly when we understand the complexity of the organisation which underlies these latest acquisitions of the modern brain, that we are driven to demand a long period of time for the changes which brought man from a Rhodesian stage to that in which we now find him. Even if we allow two hundred thousand years for the duration of the Pleistocene period, which is twice the allowance often assigned to it, the time seems far too short for the evolutionary changes we have merely glanced at. Time will show that Rhodesian man represents a Pliocene stage in our evolution.

CHAPTER XXI

THE FACE AND STATUS OF RHODESIAN MAN

THE face of Rhodesian man deserves a chapter to itself for several reasons. But for the absence of the lower jaw, it is complete, more so than in any ancient specimen so far discovered. The prehistoric skulls which can be compared with it in this respect are those of Gibraltar and La Chapelle, and in them parts of the face are missing. It is not its completeness, nor its astonishing proportions, however, which tempt me into this chapter but a reason of a totally different kind. My object is to emphasise the importance of studying the face in order that we may unravel the racial affinities of extinct types of mankind. A man's racial origin finds its surest expression in the lineaments of his face. We recognise, in our crowded streets, the Chinaman, Negro, Hottentot, European, and Malay as they pass, but not by looking at the shape of their heads ; a glimpse of their faces is sufficient to lead us to a decision. A rapid, almost unconscious, survey of a man's face—his nose, eyes, mouth, chin, cheeks, and forehead—may reveal his native country. Certainly colouring helps us, but in the study of ancient man we can have no assistance of this kind. Shape of head may also guide us. In our studies of prehistoric races we have to make the utmost use of head-shape, for unfortunately the face is fragile, and decays, or becomes broken and is thus usually missing. Happily, however, in the Rhodesian skull, the face has been preserved, thus giving us such an opportunity as has never occurred before of studying the facial characteristics of an extinct,

ancestral type of mankind.   In fig. 139, where the skull
of Rhodesian man is represented in profile, I have been
tempted to indicate, by stippled lines, the missing lower
jaw in order to give the reader a true appreciation of the
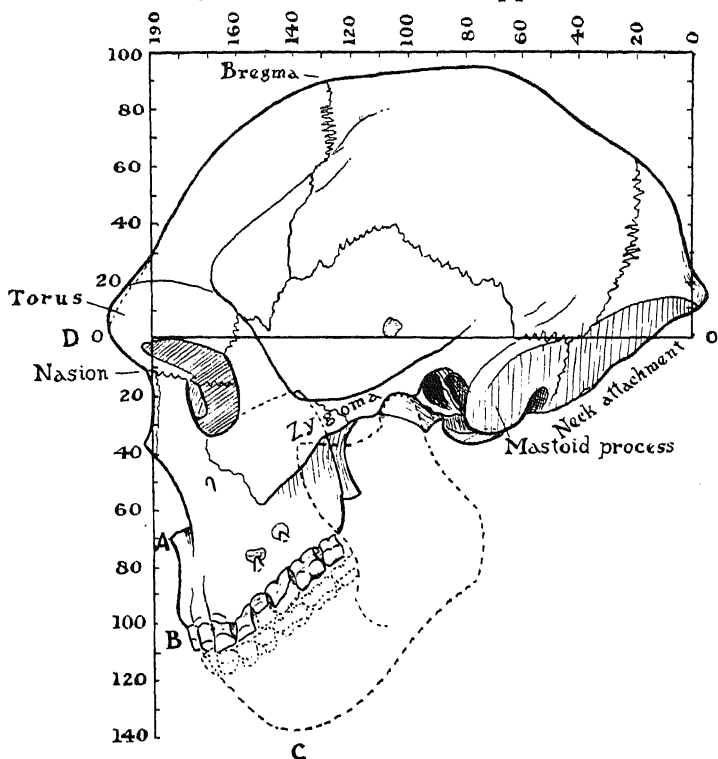
FIG. 139.—The Rhodesian skull represented in profile with stippled outline
of the missing lower jaw.

A, nasal spine ; B, prognathion or upper alveolar point ; C, lower
border of symphysis ; D, glabella.

massiveness of the face.   There are so many indications
to help us in filling in the outline of the lower jaw.   We
have its socket in front of the ear and separated from that
opening by a massive post-glenoid spine ; we have the
zygoma (fig. 139) to guide us to the forward reach of the
ramus or ascending lever of the lower jaw which was
worked by the muscles of mastication ; we have the bony

surfaces and projections from which these muscles sprang, and we can judge how strong and massive these must have been.   Best of all, we know the size and position of all the upper teeth, and from these we can infer the exact disposition of the teeth set in the lower jaw, and the strength of bone needed to carry them.   Hence the completed profile shown in fig. 139 is not altogether fanciful.

The feature which first catches the eye when the Rhodesian face is viewed in profile is the boldness of the eyebrow ridge—the supra-orbital torus ; in massiveness it outdoes that of the gorilla.   The distance of its middle point, the glabella, situated above the root of the nose, from the ear passages, seems exceptionally great.   But when we measure its distance in profile from the central point of the ear passage we find it to be 114 mm., exactly the same as in the male gorilla and in the La Chapelle skull.   In all three the distance is 11 mm. greater than is usual in the skulls of Englishmen, and 7 mm. more than is common in those of Australian aborigines.   We notice, too, how distant the front part of the jaws, the muzzle, carrying the incisor teeth, is from the ear passage.   The prognathion (fig. 139, B), when a measurement is made in true profile, is 124 mm. distant from the mid-point of the ear passage, exactly the same as in the La Chapelle skull.   This is 24 mm. more than in the face of the average Englishman, but 50 mm. less than in the average male gorilla.   The prognathism, the forward projection of the jaw, is masked in the Rhodesian skull by two circumstances—(1) the prominence of its eyebrow torus and (2) by the extreme length of the " upper " face.   The length of the latter is measured from the root of the nose (nasion, fig. 139) to the prognathion, a point between the socket of the middle incisors of the upper jaw.   In the average Englishman the " upper " face is 70 mm. long, in the La Chapelle man 87 mm., in Rhodesian man 94 mm. Herein he approached the male gorilla, in which the " upper " face measures 110 mm.   When the whole length of the face is taken into account, making our

measurement from the nasion to the point C (fig. 139), the Rhodesian man must have maintained his exceptional dimensions. In our British faces 122 mm. is a common length, in the Rhodesian man it must have been 140 mm. at least. This is 6 mm. longer than the face of the man of La Chapelle. In this measurement, however, the Rhodesian man falls far behind the male gorilla, in which a total length of 180 mm. is common. If we accept the Rhodesian type as representative of our ancestors at the beginning of the Pleistocene period, then it will be apparent how profoundly the strength of jaws and size of face have been reduced in the more recent phases of evolution.

Further, as we know the distance between the outer borders of the sockets for the jaw, we know what its width was when measured from the outer border of one condyle to the outer border of the other. This bicondylar width was 134 mm.—exactly the same as in the Heidelberg jaw. The width, although 18 mm. more than in modern British faces, is 12 mm. less than in the La Chapelle man and 20 mm. less than occurs in the male gorilla.

The bony framework of the upper face is a scaffolding in which are set the jaws, teeth, and palate. Although this framework shelters the eyes and organ of smell it is essentially part of the apparatus of mastication. It has come about in the course of man's evolution that the powers of the brain have increased while the parts concerned in mastication have been reduced. In previous chapters [1] we have fixed the status of extinct types of men by using their cranial capacity as an index—a convenient rather than an exact one—of brain power, and the area of their palate—that part of the roof of the mouth which carries the upper teeth—as an index of their vegetative or animal life. We therefore turn with some degree of interest to see what relation the area of the palate held to volume of brain in the Rhodesian man.

[1] See pp. 102, 215. On the latter page the ratio is expressed in the form of brain to palate.

The reader will gather quickly what the outstanding features of the Rhodesian palate were from fig. 140, where, in a similar framework of lines, are set out the Gibraltar palate, the palate of a male Australian aborigine, and a palate of nearly average size of an Englishman. Let
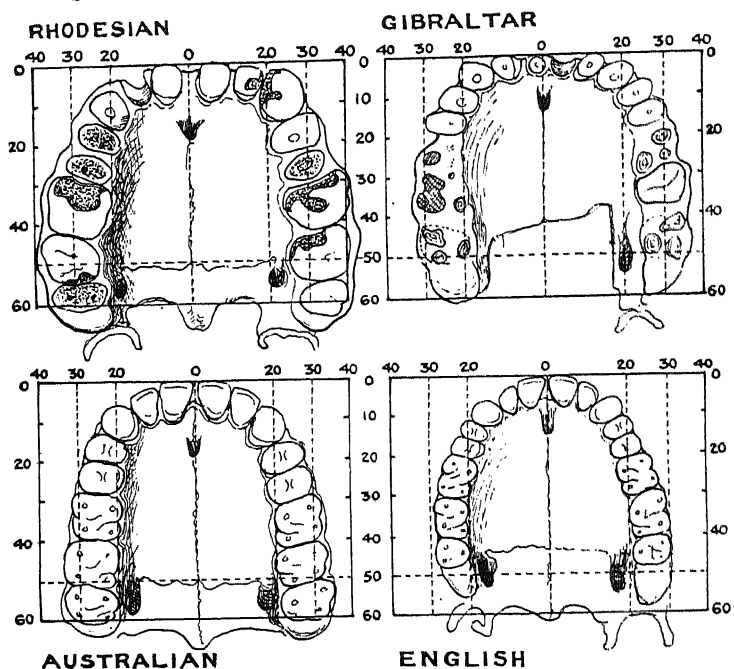
FIG. 140.—An exact drawing of the palate of the Rhodesian skull. The carious areas of the teeth are stippled. In similar series of lines are set, for purposes of comparison, the palate of the Gibraltar skull, that of a male Australian aborigine, and one of rather less than average size from an Englishman's skull.

us take note of its length first.[1] This measures 63 mm., only 1 mm. less than in the La Chapelle palate, but 9 mm. more than in the Gibraltar palate and 13 mm. more than in the palate of the average Englishman. In the exceptional palate of an Australian aborigine drawn in fig. 140, the length is 61 mm. The width of the Rhodesian

[1] The manner in which palatal measurements are taken is given on p. 101.

palate, 78 mm., is altogether remarkable; it is 4 mm. wider than the La Chapelle palate, 7 mm. wider than the Gibraltar, 10 mm. wider than that of an Australian aborigine, and 16 mm. wider than that of the average Englishman. Its area is the largest yet seen in a human skull, being just over 41·00 cm.^{2}. The average area of the English palate is 25·00 cm.^{2}; but between these two extremes we find all intermediate stages. The area of the Gibraltar palate is 31·60 cm.^{2}; of the Australian aborigine shown in fig. 140, 34·60 cm.^{2}; in the La Chapelle palate, 39·00 cm.^{2}. The palate of the Heidelberg man is estimated to have been just under 39·00 cm.^{2}. In his original reconstruction, Sir Arthur Smith Woodward gave Piltdown man a palate with an area of 53·00 cm.^{2}— certainly 13·00 cm.^{2} too much. With a palatal area of 41·00 cm.^{2} and a brain volume of 1300 c.c., it will be seen that the palato-cerebral ratio of Rhodesian man was 1 : 37·1. This ratio in the modern European usually reaches 1 cm.^{2} of palate to 55 c.c. of brain volume—a 1 : 55 ratio. In the chimpanzee the ratio falls to 1 : 8·7, and between this low ratio and the highest there exist all intermediate stages. In the Gibraltar woman the ratio of palate to brain was rather lower than in the Rhodesian man. In the La Chapelle man, owing to his great size of brain, the ratio rises to 1 : 41, almost the same as holds to-day for the male aborigines of Australia. Thus we see that the Rhodesian man while he is still in a primitive phase of the evolution of the small palate and large brain of modern man, yet in this relationship has reached far above the anthropoid scale.

In spite of its large size the Rhodesian palate has the horseshoe shape seen only in human skulls. Its width is equal to 120 per cent. of its length, a proportion which is common in the palates of living Europeans and also in those of members of the extinct Neanderthal species. In the great anthropoids, the length of the palate is usually greater than the width. The Rhodesian palate also shows other features which deserve to be noted—for instance the width of muzzle. To express this feature in

measured terms, we may take the distance between the
outer borders of the canine teeth.   In modern English-
men the bicanine or muzzle width is usually about
39 mm.; in Rhodesian man it is 53 mm.—the greatest
width ever observed in a human palate.   Anthropoid
palates have their greatest width at the side of the canine
teeth.   The Rhodesian teeth are of uncommon size, and
we can judge of the stresses to which they were subjected
in chewing by the width and strength of the bony
alveolar border or ridge in which the molar teeth were
set.   The width of this ridge where the second molars
are set is 27 mm., and the distance between the outer
alveolar borders, at this part of the palate, 85 mm.
Further, these alveolar ridges are of great depth, giving the
palate a remarkably high vault.   The height of the vault, its
distance above the chewing surface of the second molars, is
29 mm.—7 mm. more than in the modern English palate.

Until the discovery of Rhodesian man we had always
believed that caries or rotting of the teeth was a modern
disorder, an ailment which civilised man had brought on
himself by the artificiality of his diet.   It was therefore
a surprise to find that this ancient man, with enormously
strong jaws and big teeth, had suffered severely from
dental caries and, we cannot doubt, from the pangs of
toothache.   In fig. 140 the parts of the teeth which
were carious are stippled.   Of the sixteen teeth set
on the upper jaw ten are affected with this disorder.
The remaining six, including in this group the missing
incisor, are worn, but free from disease.   At the roots of
the molar and other teeth (fig. 139) abscesses have formed
and broken.   On examining the teeth of wild chimpanzees,
which had lived and died in their native forests of tropical
Africa, I found that they also suffered from caries, but
only to a slight degree.[1]   This disorder, therefore, did
not appear for the first time with the introduction of
man to civilised life, although there can be no doubt
that the discovery of cooking and artificial ways of pre-

[1] The liability of apes to dental caries is dealt with by Mr J. G. Turner,
Brit. Med. Journ., 1914, i. p. 1301.

paring food have tended to the increase of this disease. The Australian aborigine, living on his native diet, is almost free from caries, but he becomes subject to it when he adopts the white man's diet. Is it possible that the condition of Rhodesian man's teeth represents the first-fruits of the discovery of cooking ? or was it that he, like the Australian aborigine, came into contact with an imported higher civilisation which ultimately exterminated him ? [1]

We have seen that, in the typical representatives of Neanderthal man, the teeth, particularly the molar teeth, have undergone that peculiar specialisation known as taurodontism (p. 211). Rhodesian man in this respect retains the state seen in modern man and in anthropoid apes. There is no tendency in him for the pulp cavities to become enlarged ; the necks of the teeth are sharply marked off from the crowns.

The crowns of the molar teeth are remarkable for their width (13·5 mm.) rather than for their length. The total length of the three molars of the left side was 34·5 mm.—an amount which is occasionally surpassed in Australian and Tasmanian skulls. The third molars, or wisdom teeth, are reduced in size—are apparently in a state of retrogression. This in no wise militates against the antiquity and primitiveness of Rhodesian man, for in the chimpanzee we find these teeth manifesting the same degree of reduction. The tendency for the wisdom teeth to disappear has become very marked in certain modern peoples. Wisdom teeth have completely disappeared from the jaws of over 20 per cent. of English people, not even a rudiment being formed. Thus we see that Rhodesian man was provided with jaws, teeth, and palate of remarkable strength, and that his teeth do not show those peculiar changes which usually occur in the teeth of Neanderthal man. His canine teeth are no longer prominent and pointed as in the ape and as they were in Piltdown man, but have sunk to the level of their neighbours in the dental series.

[1] See note on wound of skull, disease of the knee-joint and ear on p. 417.

The first glimpse of the face of the Rhodesian skull impresses the anatomist with its resemblance to that of the gorilla. Nor does this impression weaken with further study. The face of Neanderthal man is also gorilline in appearance, but to a less degree than that of Rhodesian man. This character of the Rhodesian face is brought out in fig. 141, where, in one drawing its upper jaw is made the background on which the upper jaw of a modern Englishman has been placed, while in the adjoin-
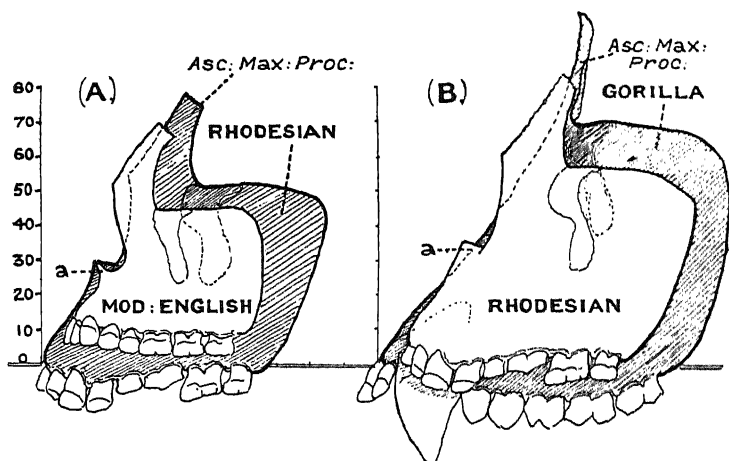
FIG. 141.—A. The upper jaw of an English skull superimposed on the Rhodesian jaw. B. The Rhodesian jaw superimposed on that of a male gorilla.

ing drawing the upper jaw of a gorilla has become the background for the Rhodesian jaw. The English specimen is outranged by the Rhodesian to about the same extent as the gorilla overshadows the Rhodesian specimen. There is, however, this remarkable discrepancy in our comparison. The canine tooth of the male gorilla is a powerfully formed fighting weapon, socketed in a beam of bone which ascends in the upper jaw by the side of the nasal opening. A reduction in the size of the canine teeth, which certainly did take place in the early evolution of certain branches of the human stock, led to a complete transformation, as well as a reduction in size, of the front

parts of both upper and lower jaws. One result of this reduction is to bring about the free exposure of the nasal spine on the face (fig. 141, *a*). In the gorilla, the nasal spine lies within the portals of the nasal aperture. The nasal spine is a bony elevation, on which the front part of the septum, or partition of the nose, is set. The further reduction of the front teeth in modern man has caused still greater exposure of the nasal spine, which comes to project from the sill of the nasal opening like a bony jib (fig. 141, A, *a*). The Rhodesian jaw does present us with a stage which carries us towards the condition of parts seen in the anthropoid nose and snout.

In previous chapters, when describing forms of fossil man, we have had occasion to remark that were these prehistoric men to return to life they might pass without detection in a European crowd. In the case of Rhodesian man this would have been impossible, the great bar or torus of bone which crossed his forehead, shadowing his wide, capacious orbits, gave his face a forbidding, gorilla-like aspect, making him unmistakable in whatever garb he might have cared to assume. From end to end this bar of bone measures 139 mm. (see fig. 142), the same amount as in the male gorilla, 15 mm. more than in the La Chapelle skull, and 31 mm. more than the supra-orbital width of the face of an average Englishman. Its thickness or vertical depth over the middle part of the orbit is 21 mm., exceeding that seen in any skull, anthropoid or human. Its thickness in the male gorilla is 14 mm., the same as in the biggest Neanderthal skulls. Why should a human forehead be provided with such a massive bar of bone ? The bony struts which carry the thrusts and stresses set up during mastication in the teeth and upper jaw ascend to the *torus*, both between the orbits and at their outer margin. Further, it will be seen that the temporal ridges (figs. 135, 142), which provide an origin for the great temporal muscles of mastication, run on to the outer ends of the torus. These ends have to support the pull of chewing muscles, particularly that part which grinds the lower molar teeth against the

upper. Clearly the *torus supraorbitalis* is needed to complete a facial skeleton which is subject to forces generated by powerful muscles of mastication.

Such an explanation does not quite account for the mass and strength of the *supra-orbital torus*; there must
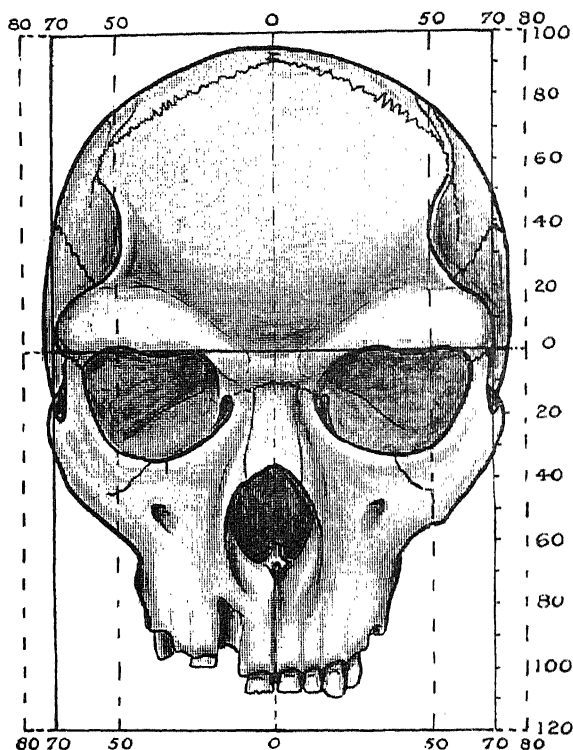
FIG. 142.—The face of Rhodesian man, drawn at right angles to the plane shown in fig. 130.

be some other factor involved. Now, it is known that emasculation does retard and alter the growth of the forehead and of its eyebrow ridges. So we may suspect that in the massive supra-orbital torus of Rhodesian man, just as is the case with the great canines of the male gorilla, we have a structure which was subject to influences exerted on the body by the sexual glands. In brief, the large torus of Rhodesian man may have

in it something of the nature of a secondary sexual character.

The likeness to the gorilla which we have been tracing in the forehead of Rhodesian man, and also in a lesser degree in that of Neanderthal man, extends to other regions of the face. In these three types we find the orbits wide, high, and capacious, because their outer and inner walls form a supporting part of a massive chewing platform. In all three, that region of the upper jaw which lies between the orbit and the teeth is not depressed and shrunken as in the cheeks of modern Europeans, but is full and rounded, rising gradually into the wide arch from which the nasal bridge emerges. The nose in all three is an undifferentiated part of the face. The nasal bones are exceptionally long in the gorilla; they are relatively long in both Rhodesian and Neanderthal man. There is in the nasal region of the face of Rhodesian man, and also of Neanderthal man, sufficient bony material for the fashioning of a prominent narrow nose of the larger European or Semitic types. The changes which gave rise to the characteristic European, and also the Semitic nose, depended to a certain extent on reduction in the size of the teeth and of the jaws, but, as we shall see later, other factors were concerned, for, like the forehead, the human nose falls in the list of structures which are altered by the removal of sexual glands.

The facial differences we have been discussing are given a diagrammatic representation in fig. 143, A, B. In the first diagram opposite halves of the Rhodesian and of an English skull have been brought against each other, the nasion of each being made to correspond. In the second diagram the same arrangement has been made between opposite halves of the Gibraltar and Rhodesian face. The differences in form between the English eyebrow ridge (representative in this case of modern races) and that of the Rhodesian face are very marked. The two elements which have become overgrown and fused in the Rhodesian torus are separated into two, the original supra-ciliary and supra-orbital element in the English forehead

We have already mentioned that the total width of the supra-orbital torus in the Rhodesian skull measures 139 mm., and that the corresponding width in an average English forehead is 107 mm. In the Gibraltar skull the width of the torus is 122 mm. But no mention was then made of another important measurement of the forehead—its minimal width, which is taken between the temporal lines as shown in fig. 4 (p. 10). In the Rhodesian skull the minimal width between the temporal lines—98 mm.—
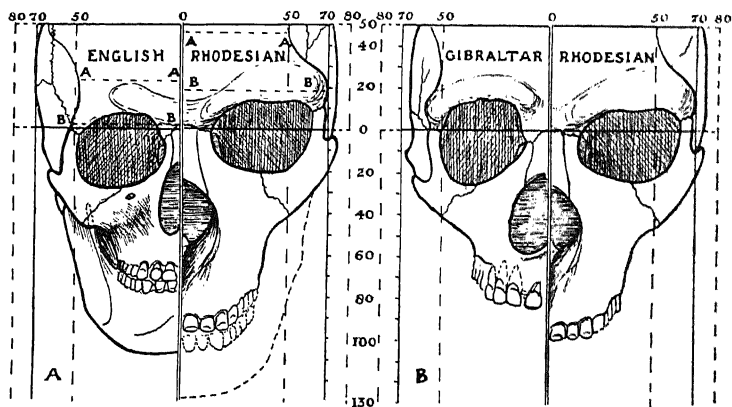
FIG. 143.—A. Right half of the facial part of an Englishman's skull placed side by side with the left half of the face of the Rhodesian skull, both halves corresponding at the nasion. B. A similar presentment of the Gibraltar and Rhodesian skulls.

lies high on the forehead, as is often the case in Australian skulls and in the skulls of apes. Now, it will be apparent that the greater the reduction in the structures concerned in mastication, the less will be the supra-orbital width. Also it will be apparent that the greater the development of the frontal lobes of the brain, the greater will be the width of the forehead. Therefore the difference between the supra-orbital width and minimal frontal width gives some indication of the stage of human evolution. This difference in Rhodesian man is 41 mm. (139 mm. −98 mm. =41). In the average British skull the difference is 8 mm. (107−99); in the Gibraltar skull, 20 mm. (122 mm. −102 mm.), while in native Australian males the mean

difference is 13·8 mm. (112·6−98·8=13·8). We again see how primitive—how ape-like—is the forehead of Rhodesian man.

The diagrams given in fig. 143 bring out the exceeding length of the Rhodesian face, but this excess is seen to be due mainly to the size of the subnasal part—the part covered by the upper lip. The nasal part measures 57 mm., the subnasal 37 mm. In the average English skull the corresponding measurements are: 50 mm., 20 mm.; in the Gibraltar face, 55 mm., 17 mm. Another feature brought out in fig. 143 is the width of the nasal opening in primitive skulls. The mean nasal width for English (male) skulls is 24 mm.; in the Rhodesian nose, 31 mm.; in the Gibraltar and La Chapelle noses, 34 mm. —the widest known.

Before leaving this rather tedious discussion of the facial characteristics of the Rhodesian man, there is one matter connected with the nose that I should like to draw attention to here. In figs. 142, 143, two borders are shown to the sill or floor of the nasal opening of the Rhodesian skull—an inner and an outer, with a groove between them. In the nasal openings of anthropoid skulls a primitive condition is seen. In them the groove shown in fig. 142, between the inner and outer margins of the nasal sill, passes uninterruptedly from the face to the floor of the nose. In the Rhodesian skull we have an early stage in the evolution of the highest human form where there is a sharp, well-defined bony margin between the nose and the face. This stage is brought about by a fusion of the outer and inner margins.[1] A sharp marginal nasal sill is found in a varying proportion of all races of mankind—living and extinct. An examination of ancient and modern European skulls has shown me that a sharp marginal sill to the nose has become more prevalent as time has gone on. Now it is a remarkable fact that this change is proceeding not

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[1] For a full discussion of the evolution of the nasal sill see a paper by Drs A. N. Burkitt and G. H. S. Lightroller in the *Journ. of Anat.*, 1923, vol. lvii. p. 295.

in one race, but in several races which are only distantly related. It occurs in many English skulls, an example being shown in fig. 143, A, and in some Neanderthal skulls, as instanced in fig. 143, B. We do find, as illustrated by the evolution of the nasal sill, that in allied species and genera certain characters may reach independently the same evolutionary end long after these species or genera have separated from a common ancestor.

We have been studying the face as seen from the front, but if we are to understand the facial peculiarities of Rhodesian man we must look at the region of his temple and cheek from the side. Our task will be made easier by consulting the outlines given in fig. 144. In the lowest drawing of the first column is shown the massive zygomatic arch of the gorilla, passing forward from the region of the ear to end on the outer wall of the orbit. The chief use of this arch is to give fixation for one of the chief muscles of mastication—the masseter, the forward extent of this muscle lying at the point marked " D." The greater the strength of this muscle, the longer and stouter the zygomatic arch. In the gorilla this arch extends so far forward that it has carried with it the outer wall of the orbit ; the anterior attachment of the masseter (D) comes to lie vertically below the nasion (B) and glabella. In Rhodesian man, the glabella extends as far forward as in the gorilla, but his zygomatic arch has retracted to human dimensions, the front attachment of the masseter (D) now lying vertically below the outer end of the torus, and below (A), the fronto-malar point. The outer wall of the orbit is thus drawn far behind the inner orbital wall, giving a remarkable obliquity to the face of Rhodesian man in its upper orbital region. It will be seen, when the Rhodesian and English conditions are compared, as in fig. 144, that the modern European face has resulted from a reduction in the region of the forehead rather than in the region of the cheek and temple. Indeed we are surprised to find in a skull with such a development of jaw as that of Rhodesian man, that his zygomatic arch, although massive in its vertical dimen-

sions, yet in its forward reach falls within measurements which are usual in modern races. Rhodesian man had
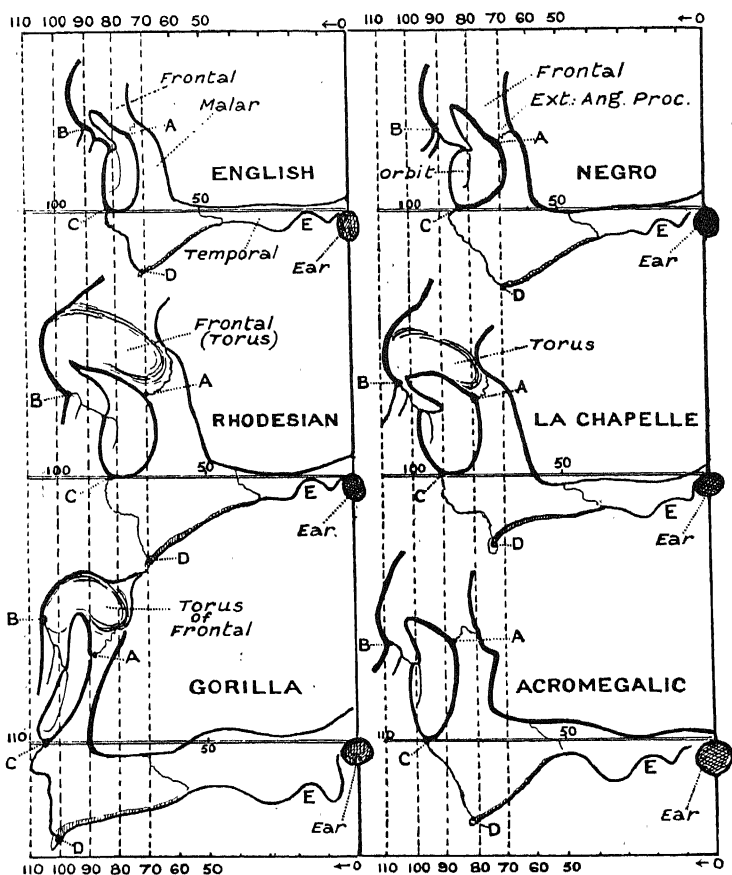
FIG. 144.—A series of drawings to show the evolutionary changes which have taken place in the side of the face—the region of the temple and cheek—during man's evolution. They are described in the text. All the specimens are oriented on the Frankfort plane—which passes from the lower margin of the orbit through the upper margin of the ear passage.

A. Anterior fronto-malar point. B. Nasion. C. Upper malo-maxillary point. D. Lower malo-maxillary point, marking the anterior attachment of the masseter muscle. E. Socket for lower jaw.

not the full, forwardly prominent cheek bones of the modern negro (fig. 144). In its forward dimensions the

La Chapelle man had a zygomatic arch which outdid
that of Rhodesian man (fig. 144), and also that seen in
modern faces, and yet the span between the right and
left zygomatic arches, which determines the width of
the face, was the same in the man of La Chapelle as in
the man of Rhodesia, namely, 144 mm. This, although
14 mm. more than is common in the faces of Englishmen,
is a dimension which we often find surpassed in individual
cases. On the other hand, the bizygomatic width of
Rhodesian man falls 36 mm. short of the measurement
usual in male gorillas. We find, however, that when
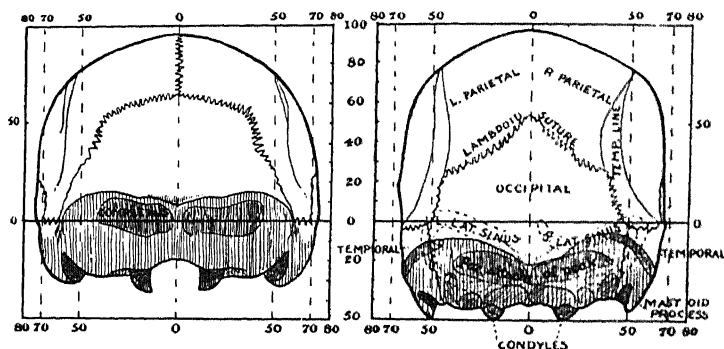
FIG. 145.—The hinder aspect of the Rhodesian skull, compared with the
same view of a modern English skull. Both skulls are poised on the
plane represented in fig. 139.

modern man becomes the subject of that strange disorder
of growth known as acromegaly, his zygomatic arch may
assume, as is shown in fig. 144, dimensions which are
greater than any found in ancient man.

There remains one other aspect of the head of
Rhodesian man to which we must give our attention. In
a muscular animal with strong jaws, the head has to be
firmly hafted to the neck; Rhodesian man is a case in
point. When we examine his head from behind and
compare it with the same aspect of a modern head, as
in fig. 145, we notice how wide is that part of the base
to which the neck is attached. In Rhodesian man the
breadth of the base of the skull, between the outer
surfaces of the mastoid processes—the bimastoid width—

is 144 mm., 6 mm. more than in the La Chapelle man, 18 mm. more than is usual in the Englishman's skull, but 12 mm. less than in the male gorilla.   His skull is seen to be wide in comparison to its height, and yet in this respect it stands intermediate to that of Neanderthal man (fig. 194, p. 552) and modern man.   As seen from behind, the head of Neanderthal man is more anthropoid than that of Rhodesian man.   It is a remarkable fact, one which has not received the attention from anatomists which it deserves, that both man and ape are born with skulls which are narrow at the base.   In childhood and youth, as the jaws and neck grow, the base of the skull expands, causing the shape of the brain to alter.   The lower or more brutal an animal is in the scale of evolution, the more does expansion of the base of the skull take place.   In this respect Rhodesian man represents an early stage in the evolution of modern man.

Not only does that part of the base of the skull to which the neck is attached grow in width as man and ape reach maturity, there is also a growth transformation which causes this part of the skull to look in a more backward direction.   This can be most clearly perceived if we superimpose, as has been done in fig. 146, the skull of a baby gorilla on that of an adult male gorilla.   In this figure it will be seen that the basal part of the baby's skull, and the occipital condyles, have to grow backwards a long way to reach their adult position.   As this basal growth takes place the upper part of the occipital bone is thrust in a backward direction (see fig. 145).   The attachment of the neck, from being under the skull, is brought to lie more on its hinder aspect.   The more primitive the animal, the greater is the backward thrust and transformation.   Here, as in so many other points, modern man has come by his distinctive characteristics by retaining throughout life conditions which are present in apes only during their fœtal stages.

That a transformation of this kind took place in Rhodesian man will be apparent from fig. 139 (p. 395) where the neck attachment is seen to slope backward

and upward, the inion rising far above the plane of orientation. An equally great transformation took place in Neanderthal man; and in occasional modern individuals a change almost as extensive may be seen, but in all modern races—particularly in black and brown races—the tendency is to inherit more and more the infantile stage. As may be seen in fig. 139,
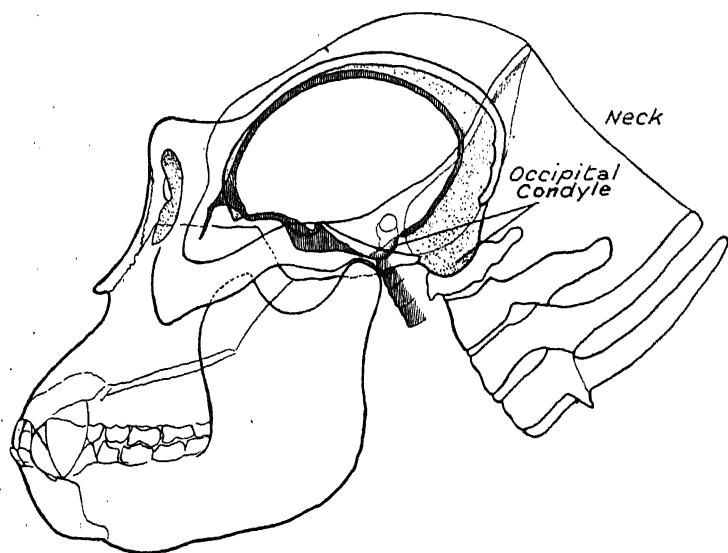
FIG. 146.—The skull of a baby gorilla (in shaded outline), superimposed on that of an adult male gorilla to show the growth transformation of that part of the base to which the neck is attached.

it was necessary for the Rhodesian neck to be thrown backwards, to give room for the movement of the massive lower jaw.

The mastoid process, which is situated behind the ear, forms part of the bony platform to which the muscles of the neck are attached. As shown in fig. 139, these processes in Rhodesian man are of the modern form, whereas in Neanderthal man they have some resemblance to the condition met with in young anthropoids. Thus we see that in his neck attachment Rhodesian man was less ape-like than Neanderthal man; he shows an ancestral

stage in the evolution of the neck attachment of modern man.

Hitherto anatomists have been content to merely discriminate and enumerate the various points of difference which separate mankind, both living and extinct, into its various types and races. We cannot leave the extraordinary series of characters which distinguish the Rhodesian type from other extinct breeds of mankind and still more from living races, without offering an explanation of how the differentiation of races has come about. The nature of the evolutionary machinery which fashions mankind into races and types is now being revealed by the study of certain strange disorders of growth to which man is liable. The most instructive of these is acromegaly, which is always accompanied by an unbalanced or pathological state of the small gland situated on the floor of the skull, under the brain—the pituitary gland.[1] The nature and extent of the growth-changes which slowly transfigure the faces, jaws, and heads of men and women who become the subjects of acromegaly are illustrated in figs. 147 and 148. In fig. 147, A, half of the skull of an Englishman who was long the subject of acromegaly is placed side by side with that of a normal Englishman; another case of the same kind is illustrated in fig. 147, B. From these figures the reader will learn that all parts of the face undergo growth and become enlarged—the forehead, the orbits, the nose, the cheeks, and the jaws. He will note, too, that these changes are gross imitations of the features we have just been studying in the face of Rhodesian man. It is clear from such cases that the pituitary gland, through substances (hormones) thrown into the blood, is concerned in regulating the size and shape of most parts of the body, particularly those of the face. There still lurks in the body of modern man the machinery which fashioned the ample features of Rhodesian man and which can be awakened under conditions of disease. It is the same machinery which determines the more exaggerated degree of bestial

[1] For further literature dealing with this matter, see p. 385.

strength seen in the face of the gorilla. Under conditions of disease, this ancient mechanism can be roused again into activity in the body and face of modern man.

In order that the reader may feel assured that the comparison I have just drawn between the features of
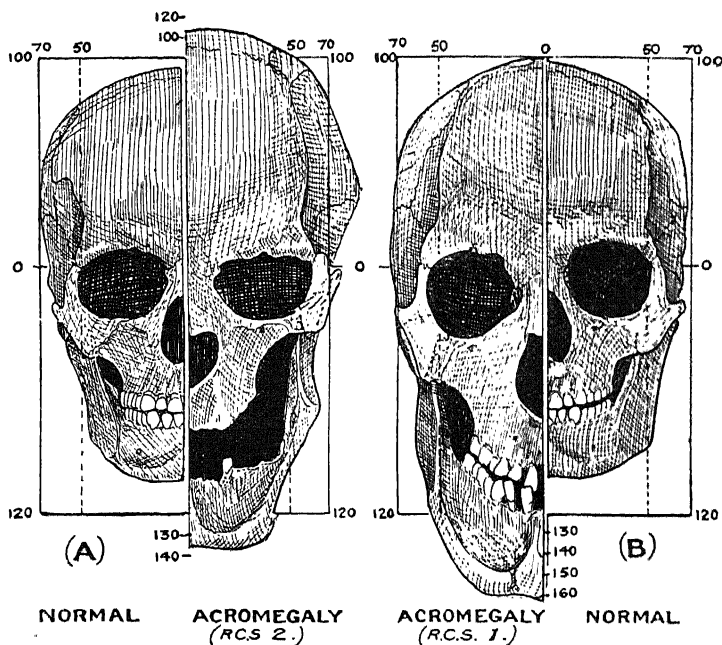
FIG. 147.—The transfiguration of the face in two cases of acromegaly.

A. The right half of the face of the skull of a normal Englishman set side by side with the left half of one who suffered from acromegaly for many years. B. Another case of the same kind, but in this instance the right half is the subject of acromegaly.

the acromegalic and those of Rhodesian man is not fanciful, but real, I give in fig. 148 a picture of the skull of a third case of acromegaly—also of an Englishman, this time viewed in profile. It will be seen that the area to which the neck is hafted has undergone changes of the same kind and degree as are seen in the Rhodesian skull (fig. 139, p. 395). And having said this much, I would beg of the reader not to jump to a conclusion which will

probably come to his mind—that the Rhodesian skull is that of an unfortunate early inhabitant of the Broken Hill cave who had become the subject of this interesting but cruel malady, acromegaly. If the faithful drawings given
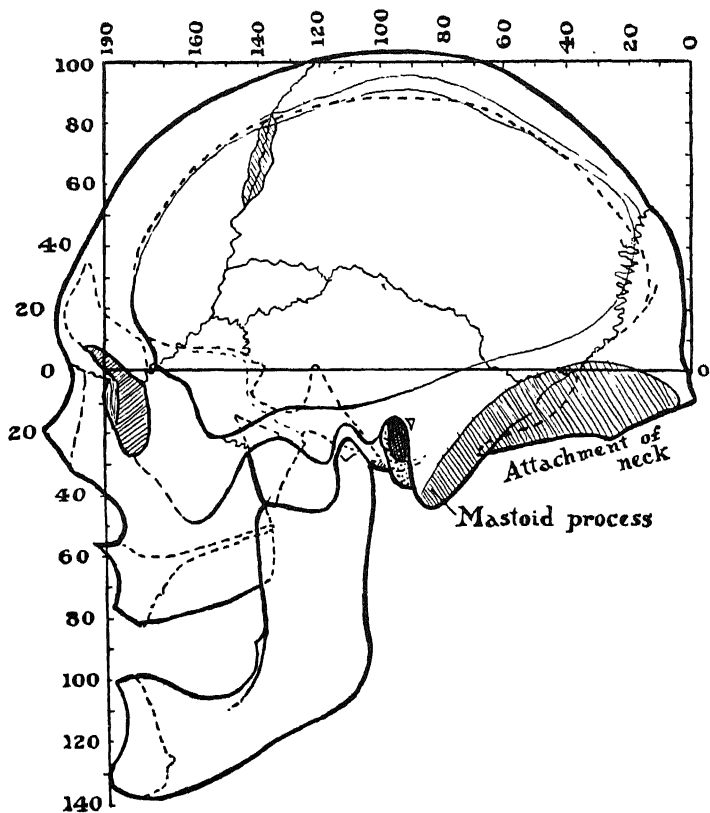
FIG. 148.—The skull of a man, long the subject of acromegaly, viewed in profile.

in figs. 147 and 148 are examined, it will be seen that all parts—the jaws, the forehead, nose, and face—have overgrown in a disorderly manner, there is distortion and lack of functional harmony between all of them, whereas in the Rhodesian skull these parts are formed stoutly and regularly and in an orderly manner—which is never the

case in acromegaly. Besides, the fossa which contained the pituitary gland of Rhodesian man is normal in its proportions. All that I maintain here is, that acromegaly does give us a glimpse of the machinery which regulates the evolution of man's body and brain ; but how this machinery is geared up and down, we know nothing as yet

Having thus reviewed at considerable length the structural make-up of Rhodesian man, we come to the main object of our survey. What is the relation of this primitive type to ourselves, to Neanderthal man, to Piltdown man, to the Java man, and to other extinct types ? In the course of our analysis his similarities to the modern type of man have been seen to preponderate, particularly his resemblance to the most primitive of all living races—the aboriginal type of Australia. But we have also had to note the many features he shared with Neanderthal man, and there are others, as we shall see, which link him to the Java man—the most primitive human type yet discovered. We leave unmentioned his resemblances to the gorilla ; he shares them with Neanderthal man. With this tale of his characters to guide us we have to determine his place in the family tree of evolving humanity. His place in this tree, as is shown in the frontispiece, and in fig. 263, is at or near the base of the stem which afterwards branched into all types of modern man—*Homo sapiens*—living and extinct. Herein lies the great importance of the discovery at Broken Hill. It has given us for the first time a glimpse of our ancestral state.

The discovery of the Rhodesian type, although most welcome, cannot be said to be unexpected. Everyone who had given Neanderthal man serious consideration, realised that he and modern man must have a common ancestry, one in which modern and Neanderthal characters were mingled. Rhodesian man nearly answers to the common ancestor we have been in search of, but not quite ; he has assumed too much of the modern type to serve this purpose. His just place seems to be in the modern stem soon after this stem had broken away from the Neanderthal line (fig. 263). It is just because his

origin lies so close to that of Neanderthal man that Rhodesian man has so much of this type still in him. He stands to the modern type in almost the same ancestral relationship as Heidelberg man does to Neanderthal man (fig. 263).

It is easier to fix the place of Rhodesian man in the scale of human evolution than to estimate his position in geological time. It may be that he was a late survival, an okapi of humanity as has been said. It is more likely that his date will prove to be early Pleistocene. We may compare the cave at Broken Hill to Kent's Cavern at Torquay. In the depths of this cavern occur implements of the early or pre-Chellean type, the type which is found in the Cromer beds. Rhodesian man came from the depths of a cavern which we have every reason for presuming is as old as Kent's Cavern.

If, then, we presume that Rhodesian man flourished in early Pleistocene times and that the Heidelberg and Piltdown types were also of this date, it will be necessary for us to conclude—if our scale of time is right—that human evolution has proceeded at a faster pace than most of us have thought hitherto. From England, Germany, Rhodesia, parts of the earth which are widely separated, we seem to have the same tale. In early Pleistocene times—less than one hundred and twenty-five thousand years ago, according to many authorities—each of these countries had its particular type of man, but in all of them an equally primitive type. It is true that we have not yet found in fossil form a kind of man which represents the immediate ancestor of modern man. We have not found the stage which lies between Rhodesian man and modern man. Notwithstanding this blank in our knowledge, the evidence which is ever accumulating makes it more and more difficult to believe that Galley Hill and other examples of modern man are really of the antiquity assigned to them on geological evidence.

Rhodesian man not only suffered from a severe degree of dental caries and dental abscesses; in his left knee-joint is to be seen a lesser degree of rheumatic change, manifested chiefly by a "lipping" of the outer

margin of the articular end of the tibia. The hip and ankle joints of the same side were sound. The rheumatoid change in the knee may be a consequence of " oral sepsis," but I see skeletons in which the teeth are diseased and the joints sound ; others where the teeth are sound and the joints affected ; and still others where both teeth and joints suffer.

Some considerable time before his death Rhodesian man received a severe wound, one inch above and in front of his left ear passage. The blow must have been given by a hard, sharp-pointed implement which left a perforation of the skull about one quarter of an inch in diameter (6 mm. by 7 mm.). The edge of the wound is healed and the undercutting of the margin shows that the implement had been driven from without inwards. Certain trails on the surface of the adjacent bone suggest that pus had formed and tracked in several directions. There is a peculiar erosion on the hinder wall of the left ear passage, large enough to take the terminal joint of a man's little finger.[1] This eroded hole is of obscure origin, but it may have been caused by an abscess which tracked behind the ear from the wound in the skull. The punctured wound lay over the second convolution of the temporal lobe. As already said, the victim lived sufficiently long to allow smoothing and healing of the edges of the bony wound.

It is a remarkable coincidence that the ear of Boskop man should also show disease of a peculiar form. The roof of the middle ear, the small cavity in which the auditory ossicles are fixed, has been eroded, apparently by disease, so that this small cavity communicates with that of the skull. From the upper part of the middle ear, an outlet has been eroded to open on the hinder wall of the ear passage (external auditory meatus). One would suppose, at first sight, that Boskop man had suffered from "middle ear disease." But there is another wide opening from the hinder wall of the middle-ear space into the groove for the lateral blood sinus, and this anomalous opening is not shaped as if produced by disease. It has the appearance of having served for the passage of a large vein—perhaps a representative of the petro-squamosal sinus. It is a remarkable circumstance that these two African fossil skulls should be marked by ear lesions of an obscure and puzzling nature.

[1] See Mr MacLeod Yearsley, *Lancet*, 17th July 1922.

CHAPTER XXII

PITHECANTHROPUS—THE JAVA MAN

Asia, with ancient civilisations in Mesopotamia, India, and China, holds out the fairest promise for students of man's early history. So far, these promises have not been fulfilled; no extinct type has been found on this vast continent in any way comparable to Rhodesian man, or even to the big-brained Bushman first found at Boskop in South Africa. Yet everywhere there are signs that Asia, too, must have been the abode of early types of men. Thirty years ago, in 1894, Dr Fritz Noetling,[1] while carrying out a geological survey in Burmah, found rudely worked flints which he believed to have come from a conglomerate deposit, one containing fossil remains of early Pliocene mammals. So long ago as 1861 Mr Le Mesurier discovered palæoliths in India; in the valley deposits of the Indus, Nerbudda, and Godavari, there occur stone implements worked in all of the ancient fashions, showing us that in most remote times Asia, Africa, and Europe were swept by corresponding waves of culture.[2] But of the kinds of men who shaped the palæoliths of India we know nothing.

[1] See *Records of the Geological Survey of India*, 1894, vol. xxvii. p. 101; also *Natural Science*, 1895, vol. viii. p. 201; 1897, vol. x. p. 89.

[2] Those interested in the anthropology of India, both ancient and modern, should consult *Principles and Methods of Physical Anthropology*, 1920, by Rai Bahadur Sarat Chandra Roy, M.A., Reader in Anthropology, Patna University, and *Prehistoric India*, 1923, by Panchanan Mitra, M.A., Lecturer in Anthropology, Calcutta. Some of Mr Mitra's statements must be accepted with reserve. A clue to recent literature will be found in an article by Mr T. H. Vines, *Man*, 1922 (March).

The oldest skulls I have seen from India are two which I described for the Anthropological Society of Bombay.[1] Although deeply buried in alluvial deposits, they are probably not more than two thousand years old, and have the small size and narrow shape which now prevails throughout the population of India from the valley of the Ganges to Cape Galle in Ceylon.   But if India has not yet given us her extinct fossil types, she does possess, among the jungle peoples of Bombay and Madras, a living fossil or survival type.   Amongst these tribes occur families which have the essential characters of the tropical African, and tell us of a time when the great negro stock extended as a belt across the world from the west coast of Africa to the farthest point of New Guinea and beyond.

In ancient times, man had already made a home in Siberia, for in the valley terraces of the upper waters of the Yenesei, to the north of Mongolia, there occur stone implements of all the Palæolithic cultures.   Recently (1924) a discovery of the highest importance has been announced on the eastern frontier of Tibet by two French geologists, Fathers Licent and Teilhard de Chardin.   The region explored by them is drained by upper tributaries of the Hwang-Ho, being nearly 10,000 feet above sea-level and 1000 miles inland from the coast of China.   A tributary of the Hwang-Ho, the Shara Osso Goh, has cut a deep gorge through valley deposits. At a depth of 60 metres (nearly 200 feet) in the side of this gorge fossil remains of six individuals have been extracted,[2] one "with retreating forehead and large orbits."   With the human remains there occurred fossil bones of rhinoceros, horse, bison, camel, deer, and elephant.   There were also numerous rude implements of quartzite found with the human remains.   From this announcement one may safely infer that the actual remains of Palæolithic man have at last been discovered north of the Himalayas.

In the meantime British anthropologists await with

[1] *Proc. Anthrop. Soc. Bombay*, May 1919.
[2] See *Nature*, 9th February 1924.

interest a full account of the kind of man discovered by their French colleagues in this remarkable gorge which lies within the Chinese province of Kansu. On the evidence at their disposal, anatomists feel confident that Mongolian features, such as we see in typical Chinamen, are, like those of representative African negroes, the products of recent evolution. Scattered throughout the remoter parts of eastern Asia, in lands where races with Mongolian features now prevail, there are remnants of a type which recall the physiognomy of American Indians. It is out of such a type that the modern Mongol seems to have been evolved.

If our search for traces of ancient man on the continent of Asia has yielded promises rather than actual payments, a visit to the island of Java will make amends. The fauna of this island, like that of its great neighbours, Sumatra and Borneo, tell us in the plainest terms that all three islands are severed parts of the continent we are now surveying. In all three we find species of the gibbon, the most ancient and primitive of anthropoid apes ; its ancestral type lies at the base of the stem which has branched in great anthropoid and human forms (fig. 266). In Sumatra and Borneo survive varieties of the orang, a great anthropoid, which is second cousin to the chimpanzee and gorilla of Africa. All of these facts raise expectations as to the possibilities of Java as a home of dawning humanity. And such expectations have come true, for between September 1891 and October 1892 Java gave up the remains of a being which, after thirty years of debate, still retains an undecided place between the realm of ape and man. Dr Eugene Dubois, who discovered the remains of this strange form, named it *Pithecanthropus erectus*, because, although it possesses the human erect posture, it yet possesses many ape-like traits.[1]

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[1] The more important papers on Pithecanthropus are : Dr Eugene Dubois, *Pithecanthropus erectus, Eine Übergangsform*, Batavia, 1894. Professor G. Schwalbe, " Studien ueber *Pithecanthropus erectus*," *Zeitschrift für Morphologie und Anthrop.*, 1899, Bd. i. pp. 16–240. Dr Eugene Dubois, *Trans. Roy. Dublin Soc.*, 1896, vol. vi. p. 1.

Dr Dubois saw in this ancient being the representative of an extinct family of animals which occupied a position between the human family on the one hand and the anthropoid family on the other. Pithecanthropus, in the opinion of the discoverer, was but the harbinger of a family of " missing links."

The story of the discovery of Pithecanthropus is well known. The site lies on the east bank of the Solo or
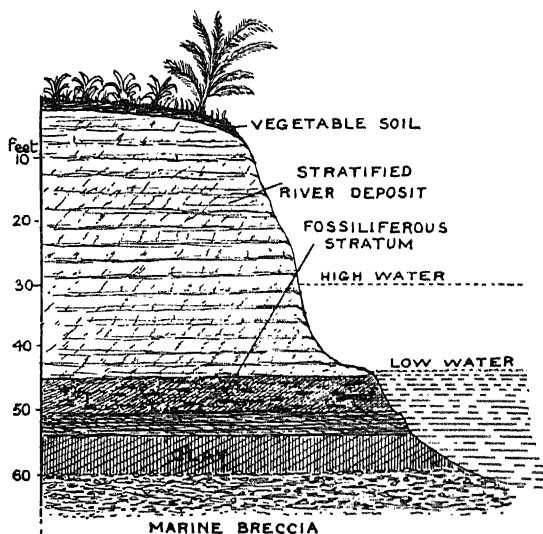
Fig. 149.—Section of the east bank of the Bengawan, near Trinil, showing the position of the fossiliferous stratum. (After Dubois.)

Bengawan, a stream which, rising among the volcanic hills of the province of Madiun, in the central part of Java, pursues a north-easterly course to the sea (fig. 154, p. 439). A native hamlet named Trinil is near the scene of Dr Dubois' explorations. A section of the deposits which form the east bank of the Bengawan, with the stratum in which the remains of Pithecanthropus were found, is shown in fig. 149.

The deposits are of the kind we have already studied in the river valleys of Europe. The stratum which directly concerns us is the fossiliferous bed, about 4 feet

in thickness, lying at the level of the present stream—
the Solo or Bengawan. The fossiliferous stratum is well
named. Between 1891 and 1894, Dr Dubois removed
from this layer fossil bones representing twenty-seven
different kinds of mammals—most of them belonging
to species which are now extinct. After comparing the
animal remains thus discovered with those which are
found in Pliocene and Pleistocene deposits of India,
Dr Dubois came to the conclusion that the fossiliferous
stratum must be assigned to a late part of the Pliocene
period. The section of the Trinil strata reproduced
in fig. 149 is therefore comparable with that of the
Cromer forest beds given in fig. 111, p. 306. Below the
fossiliferous bed is a stratum of conglomerate, repre-
senting the gravel bed of the ancient Bengawan. Under
the conglomerate is a layer of clay—a deposit laid down
in quiet, muddy water. Under the clay rests a marine
deposit containing fossil shells of early Pliocene forms
—corresponding to the " Crag " formations of East
Anglia. Over the fossiliferous bed in which the remains
of Pithecanthropus were found are stratified deposits
amounting to 45 feet in thickness. These stratified
beds of sand and fine, volcanic débris recall the Mauer
sands overlying the Heidelberg mandible. Both at
Trinil and Mauer the strata represent valley deposits.
The fossiliferous bed, made up of a fine, triturated
deposit of volcanic ashes and sand, represents the basal
layer. After the valley deposits had been laid down
during a period of subsidence, elevation of the land
commenced, the stream then cutting a new valley out
of its old deposits and exposing the deeper strata on
its banks. Dr Dubois, who was a surgeon in the
colonial military service of Java at the date of this
discovery, and who is now Professor of Geology in the
University of Amsterdam, came to the conclusion that
the animal remains in the fossiliferous layer belong to a
late phase of the Pliocene period—one corresponding
to the forest beds of East Anglia. The remains of
Pithecanthropus, which were discovered in this stratum,

would thus belong to a somewhat earlier date than the Heidelberg mandible.

To settle the date more definitely, and in the hope of finding further remains of this fossil humanoid form, Frau Lenore Selenka, with assistance from certain scientific societies in Germany, fitted out an expedition in 1906 to continue Dr Dubois' exploration at Trinil.[1] From one point of view the expedition was eminently successful. A great harvest of fossil forms was collected, but no further trace of Pithecanthropus was discovered. Seventeen specialists examined and described the great collections brought home by the Selenka expedition. The conclusion drawn by Dr Stremme and Dr Janensch from a study of the mammalian remains was that the fossiliferous bed was late Pliocene in date of formation, but those who examined the other collections fixed its date in the older Pleistocene. In this also we see a resemblance to opinions on the Cromer forest beds, which oscillate in the geological scale on either side of the border-line between Pliocene and Pleistocene.

We now proceed to examine the kind of being who lived in Java apparently when the Cromer forest beds were being formed in Norfolk. The picture has to be built from (1) the vault of a skull; (2) a left thigh bone; (3) three teeth, two of them belonging to the upper molar series—a second of the left side, a third or wisdom tooth of the right side—the third or remaining tooth being a second lower premolar of the left side.[2] There can be no doubt that the parts, if not belonging to the same individual, at least all belong to the same species.[3] They were found

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[1] *Die Pithecanthropus Schichten auf Java*, M. Lenore Selenka and Professor Max. Blanckenhorn, Berlin, 1911.

[2] In 1924 Dr Dubois added to the above list a fragment of a lower jaw, found in 1890 at Kedung Brubus, 24 miles E.S.E. of Trinil. The fossiliferous stratum in which it lay is of the same age as that at Trinil (see footnote on p. 427).

[3] This view is not accepted by many competent anatomists, who would assign the thigh bone and teeth to man and the skull-cap to an extinct form of ape. See Professor Ramström's " Der Java-Trinil Fund," *Upsala*

at the same horizon of the fossiliferous stratum. There is no question of a burial here, for the various parts were scattered over a distance of twenty paces—spread, apparently, by the running waters of the stream. If we do not admit that the femur, the teeth, and the calvaria, which lay near each other in the bed of an ancient stream, are parts of the same individual or same kind of individual, then we must make a very improbable supposition. We must suppose that the femur is that of a man showing a few, minor, ape-like traits ; that the teeth are from another human being in which certain simian features were manifest ; and that the calvaria belonged to a large-headed anthropoid showing marked human affinities. We cannot conceive that chance could bring three such strange individuals side by side in one narrow area of the bed of a stream. With Dr Dubois, we think there is only one explanation—they represent parts of the same individual.

How difficult it is to fix the exact position of Pithecanthropus in the common family tree of man and ape becomes manifest when we consider the structural characters of the thigh bone, the teeth, and the skull. The thigh bone is less ape-like in its general form, and in its individual features, than the thigh bone of Neanderthal man. The human thigh is moulded to suit the needs of a body balanced perfectly on the lower extremities. If a thigh bone has a human form, we infer that the animal to which it belonged had a human gait and a human posture of body. We infer that the feet, the legs, the pelvis, the backbone, trunk, and neck of such an animal were all shaped and adapted as in modern races of mankind. The Trinil femur signifies a being adapted to the

Läkareförenings förhandlingar, 1921, vol. xxvi. pts. 5, 6. In the author's opinion such an opinion is a mistaken one. In the evolution of the human body, as in the evolution of a civilisation, certain parts or systems may undergo great changes while others may remain almost unaltered. The same problem will come up for discussion in the case of the find at Pilt-down. The lower jaw of the Piltdown man has been assigned to a chimpanzee. Evolution is true and we should expect to find extinct forms which show mixtures of human and simian characters in their make-up.

upright posture. The erect posture was already evolved in Pithecanthropus. Those who have studied the complex structural changes needed to adapt the human body to its peculiar posture cannot conceive that such changes have been evolved twice—once in the human ancestry, and at another time in the forerunners of Pithecanthropus. The natural inference is that the human family of ancient Java and all human races are the common descendants of a stock in which the human posture and method of progression were already evolved. In stature, shape, and weight of body, Pithecanthropus was human. Dr Dubois estimates from the length of the femur (455 mm.) that the stature should have been about 5 feet 8 inches (1·700 m.), and the weight about 11 stones (70 kilos).

From the three teeth discovered by Dr Dubois, one infers that the dentition was, in the main, human in type. No trace is to be seen in the molars of an expansion of the pulp cavity or of a shortening of the roots—characters of the Heidelberg dentition. The roots of the molar teeth of the Java individual are widely separated as in apes, and as in the more primitive races of modern man. The crowns of the teeth are large, and their humanity is made manifest by the fact that their transverse (cheek-tongue) diameter is absolutely and relatively great as regards the long diameter. In simian teeth the length exceeds the width of the crown. In some minor features there is a resemblance to the molar teeth of the orang. The upper wisdom tooth (third molar), although of great size, being 15 mm. in width by 11·3 in length (the corresponding diameters in a native Tasmanian are 12 × 10·5), yet shows a manifest reduction in development. The two posterior cusps have become reduced to form a crenulated, hinder margin on the crown instead of distinct cusps. As to the development of the canine teeth, a guarded statement must be made. The temporal ridges on the skull, being only slightly developed —as compared with their condition in the skulls of anthropoid apes—suggest small temporal muscles and canine teeth reduced to human dimensions. It will be

seen in a subsequent chapter that I applied a similar process of reasoning to the skull found by Mr Charles Dawson at Piltdown. The subsequent discovery of a pointed canine tooth, which apparently belongs to the same individual as the skull, showed that this line of reasoning cannot be relied upon.[1]

If in build of body and form of teeth Pithecanthropus possessed just those features one would postulate for a primitive form of man, it is otherwise as regards the skull. When closely examined, its simian rather than its human characters force themselves on our attention. In fig. 150 the Trinil calvaria is placed within the standard frame in which skulls of the modern human type have been set. As regards length, it falls well within the range of human dimensions, being only 5 mm. short of 190 mm., the standard used for human skulls on the various comparisons made in this book. When we analyse the various elements which go to make up the length of the skull—the length of the brain, and the thickness of the supra-orbital wall in front, the occipital wall behind— we see that the proportion of bone to brain is much greater

[1] As these sheets were passing through the press the Author received from Dr Dubois a paper in which most important additions are made to our knowledge of Pithecanthropus. In this paper, which is published by Dr Dubois in the *Proceedings of the Royal Academy of Science, Amsterdam* (1924, vol. xxvii., Nos. 5, 6), there are reproduced excellent photographs of the calvarium from six aspects, of its endocranial cast from five aspects, of the fragment of the mandible, already mentioned, and of the three teeth. The mandibular fragment carries part of the socket for the right canine tooth ; the size and shape of this socket show that the canines were not simian in size and shape, but were as in modern man. Further, the chin region was moulded, not as in apes, but as in primitive man. The endocranial cast reveals the convolutions of the frontal lobe of the brain with remarkable distinctness, and every expert will agree with Dr Dubois' pronouncement—that the convolutionary pattern is " altogether human." His final verdict is " that Pithecanthropus should be considered a member of the family Homidæ " ; he would now assign to him the status of a genus in this family. In this paper Dr Dubois again emphasises the many points in which the skull-cap of Pithecanthropus resembles that of gibbons—a comparison which the Author has made in figure 151. Dr Dubois gives 184 mm. as the length of the calvaria, and 131 mm. as its width.

in Pithecanthropus than in modern man.   His brain
cavity measured 155 mm. in length, the supra-orbital
wall, 23 mm., the occipital, 7 mm.   The bony walls make
up over 16 per cent. of the total length, whereas in
modern man they usually form about 7 to 9 per cent.
of the total length.   In the Rhodesian skull, as we have
seen (p. 386), the bony walls constitute over 18 per cent.
of its total length.   In the gorilla the bony walls may
form 25 per cent., or more, of the total length of the skull.
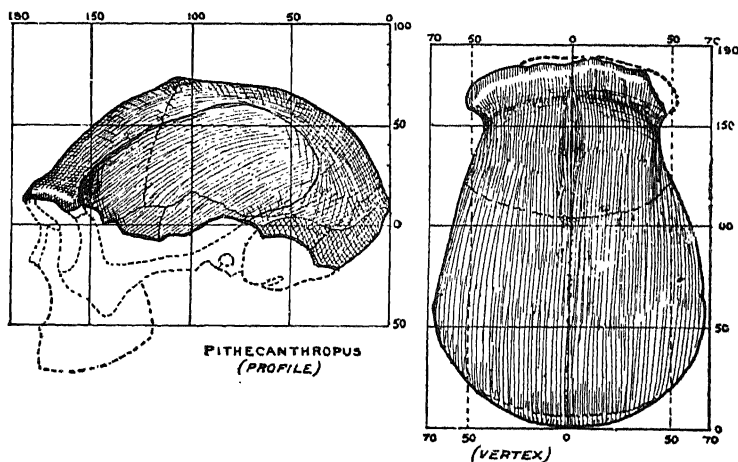
FIG. 150.—Profile and vertex of the cranium of Pithecanthropus, from
a cast of the original.

The width of the Trinil skull may be estimated at
135 mm., but only 7 mm. of that amount represents
the side walls of the skull, which are thin.   The width
is 72·5 per cent. of the length.   Pithecanthropus thus
falls into the long-headed group of humanity.   If we
make his skull comparable with that of Europeans by reduc-
ing its length 16 mm. on account of the prominence of
its supra-orbital torus, then the head-index of the Java
man rises almost to 80, bringing him to the verge of the
round-headed group.

How low Pithecanthropus must be placed in the human
scale—how very simian he was—becomes manifest in
the low pitch of his cranial vault.   We have hitherto

measured the height of the vault from the ear-holes, but there are two reasons why that base line must be abandoned in this case : (1) because the temporal bone and ear passage are missing ; (2) because in anthropoid skulls—to which that of Pithecanthropus has certain unmistakable resemblances—the ear-holes bear a different relationship to the cranial cavity to that obtaining in human skulls. We must therefore fall back upon another zero or base line—one which can be applied to the Java fragment. The base line is that shown in many of the illustrations in this book (see fig. 100, p. 280). Even when such a base line is used we meet with a difficulty. Our base line crosses the hinder lower angle of the parietal bone. That angle is present in the calvaria of Pithecanthropus, and can be utilised (fig. 150). In front the zero line should cross the fronto-malar junction, but, as will be seen in fig. 150, this line is made to pass nearly 10 mm. below this junction. The line is placed at such a low position because the fronto-malar junction in anthropoid skulls is situated much higher, as regards the floor of the brain cavity, than in human skulls. This point will be again discussed when we come to deal with the Piltdown skull (see p. 582). It is sufficient at present to draw attention to the fact that the bones forming the side of the skull behind the fronto-malar junction, the frontal and sphenoid (fig. 150), are disposed, not as in human skulls, but as in those of anthropoids (see fig. 210, p. 584). That is an important fact in fixing the position of Pithecanthropus in the scale of human evolution. In the fronto-malar region of the Java skull all the anthropoid traits are retained.

The importance of the height of the vault of the skull above this zero line (fig. 150) is readily understood. As the brain grows in size and complexity, the extra room required is obtained—as Professor Arthur Thomson clearly demonstrated fifteen years ago [1]—by the expansion of the roof and sides. The vault rises above the base

[1] "On Man's Cranial Form," *Proc. of Internat. Medical Congress,* Madrid, 1903.

line as the brain grows. In average skulls of the modern type the vault rises about 100 mm. above this standard line; in the Gibraltar skull—the lowest pitched of all Neanderthal skulls—the vault rises to 86 mm. above the zero line, in the Rhodesian vault to 95 mm., but in Pithecanthropus the height is only 74 mm. (fig. 151). In the great anthropoids—the orang, chimpanzee, and
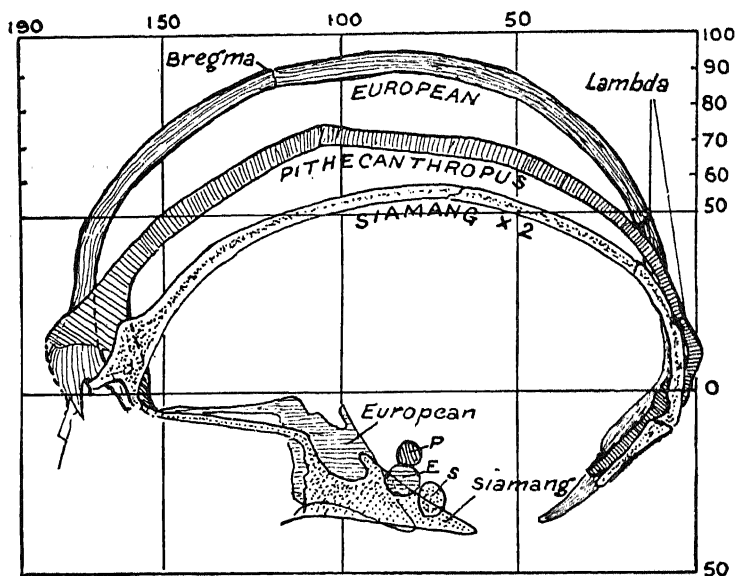
FIG. 151.—Cranial vault of Pithecanthropus, of the Siamang (gibbon), and of a modern European orientated on the zero base line. The Siamang's skull is represented twice its natural size.

gorilla—the height of the cranial vault varies from 50 to 60 mm. above the base line. Thus in height of cranial vault Pithecanthropus is rather nearer to the anthropoid than to the human form. In total length and width of brain, however, Pithecanthropus is altogether human.

There is another important anthropoid feature in the vault of the Java skull. When human skulls, whether of the Neanderthal or modern types, are orientated on the base line employed here, the highest part of the vault lies between 1½ and 2½ inches (35 to 50 mm.) behind

the bregma (see fig. 151). But in anthropoid skulls the bregma itself forms the highest point. In this respect the skull of Pithecanthropus is anthropoid (fig. 151). In the vault of the Rhodesian skull there is an approach to the anthropoid condition. This feature of the cranial vault depends on two factors. We have already seen that in anthropoid skulls, and also in the Gibraltar skull, the base is markedly extended or unbent at the pituitary angle (see fig. 80, p. 220). The extension of the cranial base leads to a flattening of the roof of the skull. Another factor, probably a more important one, in raising the vault of the skull so that its highest point is post-bregmatic in position, results from the great growth of that part of the brain which lies under the parietal region of the vault. This part of the brain is known to carry the areas of cortex which control the voluntary movements of the body and others which have to do with the storage and application of knowledge. In the course of the evolution of the human brain these subparietal areas have undergone a great growth and expansion. Such a growth tends to raise the part of the vault under which the parietal areas are situated. We should expect these parietal association areas to be of relatively small development from a mere inspection of the Pithecanthropus skull. As a matter of fact, such is the case. Dr Dubois succeeded in taking a cast of the cavity of the skull. The cast showed very clearly the convolutionary pattern of the brain. He noted that in the region of the parietal association areas the brain was poorly developed.

The forehead of Pithecanthropus shows many anthropoid features. It is low and receding; the orbits are crossed by a true simian bar of bone—the torus supra-orbitalis. This gorilla-like feature is one which also persists in Neanderthal man and Rhodesian man. The forehead is very narrow—only 84 mm. when measured between the temporal lines. In human skulls these lines diverge as they ascend on the frontal bones; in anthropoid skulls they approach towards each other as they pass backwards on the forehead. In Pithecanthropus the temporal

lines run almost parallel with each other.   This condition
represents a developmental stage of young anthropoids.
The minimum width of the forehead in Pithecanthropus,
as we have seen, is 84 mm.—10 to 20 mm. less than is
common in modern skulls ; but as regards the width just
above the orbits, the measurement is about the same as
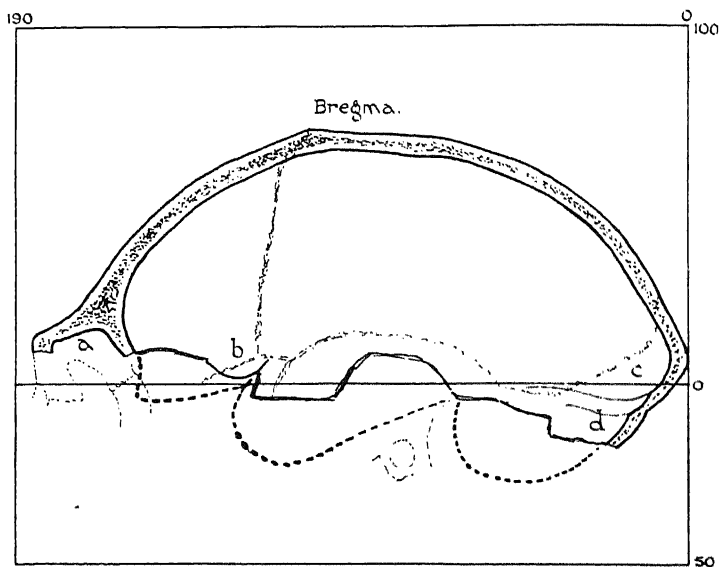
FIG. 152.—The skull-cap of Pithecanthropus as it would be seen if laid open
from front to back in vertical section.   An outline of the endocranial
cast has been placed within it to represent the brain.   The thickly
stippled outlines indicate the probable size of the parts missing from
the frontal and temporal lobes and from the cerebellum.   The frontal
sinus is shown in section (a), and (b) marks the " orbital " part of
the third frontal lobe, (c) occipital lobe, (d) cerebellum below lateral
sinus.

in modern skulls—102 or 104 mm. less than in
the more robust Neanderthal skulls, and 35 mm. less than
in the Rhodesian skull.   These small dimensions, and
other features, render it possible that the skull may be
that of a woman, not of a man.

In Pithecanthropus the head was attached to the neck
exactly as in a young anthropoid ape (see figs. 146, 150,
208).   The occipital lines, which limit the area to which
the muscles of the neck are attached, and which spread out

on the skull as the muscles of the neck grow, almost reach the upper border of the occipital bone in Pithecanthropus. The point named, the " lambda," is situated at the upper border of the occipital bone (fig. 151). In the skulls of adult anthropoids these lines ascend above the lambda. The mastoid processes are broken away, but we may safely presume that they were shaped as in young gorillas—mere bosses, not projecting, pyramidal processes as in modern man. Thus in the region of the orbits, and in the manner in which the skull was fixed to the neck, Pithecanthropus had much more in common with Neanderthal man and with anthropoid apes than with men of the modern type.

If we knew only the calvarium, if Dr Dubois had not discovered the human-like thigh bone, then we should have regarded Pithecanthropus as a big form of anthropoid. The brain cast, however, would probably have made us hesitate in coming to such a conclusion, for in the cast Dr Dubois was able to recognise many human characters. The brief preliminary [1] description which he published in 1898—the final description and figures have just appeared—suggested a very primitive form of human brain. He estimated the brain capacity to have been about 855 c.c.; this he has now (1924) increased to 900 c.c. In size of brain Pithecanthropus takes a place between the great apes and the various races of man. In orangs, chimpanzees, and gorillas the brain capacity varies from 290 c.c. to 610 c.c., the mean for male gorillas being 518 c.c. In human races the brain capacity varies from 1300 c.c. to 1500 c.c., but the capacity may be as low as 930 c.c. or as high as 2000 c.c. Clearly, in size of brain, Pithecanthropus is a transitional form between man and ape. If the specimen found represents an average individual, then we may suppose, as Dr Dubois has postulated, that in this humanoid race the brain capacity ranged between 710 c.c. and 1060 c.c.

[1] " Remarks upon the Brain Cast of *Pithecanthropus erectus*," *Fourth Internat. Congress of Zoology*, Cambridge, 1898, p. 78. *Journ. Anat. and Physiol.*, 1899, vol. xxxiii. p. 273.

" The most peculiar feature of the brain cast," writes
Dr Dubois, " is the narrowness of the frontal part of the
cerebrum, whereby it differs from every normal human
brain, as from all ape brains.   In the frontal region the
convolutions are perfectly distinct.   The most conspicuous
feature is the second frontal fissure, as clearly developed
as in any human hemisphere. . . . The important inferior
frontal convolution has attained a fair development.   I
found the average area of the exposed superficies equal to
half the average area in twelve European hemispheres,
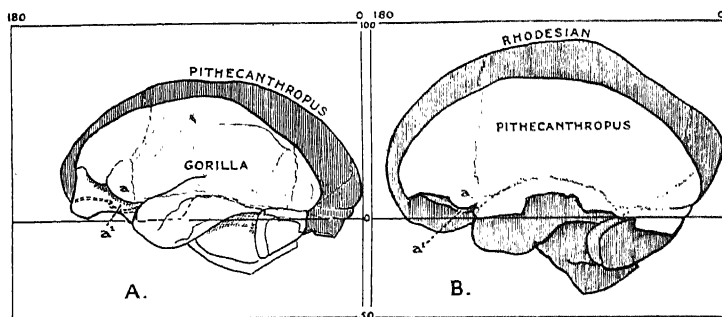
Fig. 153.—A. An outline of the endocranial cast of Pithecanthropus (see
      fig. 152), with the outline of the corresponding cast of a young
      gorilla placed over it for purposes of comparison : *a, a'*, orbital part
      of the third frontal convolution.   B. Outline of the endocranial
      cast of Pithecanthropus, superimposed on the corresponding cast
      of Rhodesian man.

but at least double that in the brain of a large chimpanzee
or an orang-utan.   This seems to indicate that our fossil
being possessed already a certain amount of power of
speech.   The pars triangularis is present in this convolu-
tion, as results from the presence of two anterior branches
of the Sylvian fissure.   But the pars orbitalis has only
a very rudimental development."

   Lately [1] Dr Dubois has published a drawing which
gives a profile of the endocranial cast in outline ; this
profile has been shown fitted within the skull-cap in fig.
152.   The outlines shown in fig. 153 will assist the reader

in realising how poorly this early humanoid form was endowed in size of brain.   In fig. 153, A, the endocranial cast of a young gorilla has been poised against that of Pithecanthropus.   For purposes of a just comparison the gorilla's cast has been placed too far forwards, but it has been given this position to bring the area of its third frontal convolution (*a*) directly over the corresponding area of the Java cast (*a'*).   In fig. 153, the endocranial outline of Pithecanthropus has been superimposed on that of Rhodesian man.   It will be seen that in the rise and expansion of the cerebral hemispheres, the primitive inhabitant of the Broken Hill cave overtopped the Java man to an even greater extent than, in this respect, the Java man did the highest form of anthropoid ape.   If outfit of brain is the essential mark of humanity, then Dr Dubois was altogether right when he described Pithecanthropus as *eine Übergangsform.*

It is clear, from Dr Dubois' account, that the region of the brain which is connected with the essentially human gift of speech was not ape-like in Pithecanthropus. The parts for speech are there ; they are small, but clearly foreshadow the arrangement of convolution seen in modern man.   In another equally important region of the brain—in that part of the parietal lobe which lies between the primary centres for sight, hearing, and common sensation—there is a simple, rather pithecoid condition.   In this intermediate region the higher association areas are developed in the brain of modern man—areas in which memories are formed in connection with things heard, seen, or touched.   In this area the brain of Pithecanthropus had not reached a " human " level.

Taking it all in all, Dr Dubois' discovery in Java throws more light on the earliest phases of man's evolution than any other yet made.   We were not prepared to find a stage in human evolution where the erect posture was fully developed, and yet one in which the brain remained in so primitive a condition as in Pithecanthropus.   We had pictured man rising to his present estate by a gradual

and simultaneous change in all his parts. In Pithec-anthropus we find a being human in stature, human in gait, human in all his parts, save his brain. The full development of the brain came last. Even in Pithec-anthropus the parts of the brain connected with the faculty of speech are present; whether speech was actually evolved is a moot point; at least we may think the potentiality was there.

All the structural characters of Pithecanthropus, so far as we know them, are exactly of the kind we expect to find in an early ancestral type of man. Does Pithec-anthropus, then, represent the stage of evolution man-kind had reached at the end of the Pliocene period? Can we conceive, keeping in mind the extraordinary complexity of the modern human brain, that the simple brain, human in form as it is, could have expanded into the brain of modern man, with its crowded, highly evolved " association " areas, in the course of the Pleisto-cene period? We know for certain that men of dif-ferent species—Neanderthal and modern—were evolved by the middle of the Pleistocene period with brains just as complex in form and large in size as the modern brain. We have seen that a period of ten, twenty, or thirty thousand years can pass and leave the human brain almost unaltered. Can we conceive that in the stretch of time between the end of the Pliocene and the middle of the Pleistocene, even allowing two or three hundred thousand years for that space, the brain of Pithecanthropus could have evolved into the modern human form? I cannot credit such a rapid rate of evolution.

We see, however, in all forms of animal life, the persistence of certain archaic types—certain groups of animals retain the characters of ancient stocks, while their cousins or collaterals branch out into new forms. The fish is an older form than the amphibian, the amphibian is older than the mammal, but all three types still survive. The gorilla of to-day is not a human ancestor, but retains, we suppose, in a much higher degree than man does, the structural features of the

stock from which both arose. It is in this light I would interpret Pithecanthropus; a true survival, into late Pliocene or early Pleistocene times, of an early stage in the true and direct line of human evolution—a stage we may expect to find already evolved in deposits, not of the Pliocene, but of the preceding or Miocene period. Hence, in the human family tree (fig. 263), Pithecanthropus is depicted as branching away from the main stem, which continued to grow in brain as time went on, while his stock made its way through the whole extent of the Pliocene with its Miocene outfit but little changed.

CHAPTER XXIII

THE WADJAK AND TALGAI MEN

If Dr Eugene Dubois had been born in the sixteenth century his spirit of adventure would have found its outlet on the Spanish Main, but being added to the population of Holland in the latter half of the nineteenth century, when Darwinian ideas were spreading across Europe, he went in search of the " missing link." Having finished a training in science and medicine at the University of Amsterdam in 1888, he became a military surgeon, choosing Java for his service. Before setting out for that island, he promised his fellow-students, in all seriousness, to bring home the " missing link." And he made his boast good, for in 1894 he returned with the fossil remains described in the previous chapter. But he also had in his possession then certain other fossil remains of man, of which, for reasons of his own, he said nothing, until May 1920—twenty-six years after his return from Java.[1]

To understand the nature and importance of this additional discovery it is necessary to glance at the geography of the " hell " of Java—the province of Madiun, in which Pithecanthropus was found. As may be seen from the sketch map given in fig. 154, mountains rise from the southern seaboard of this province, Mt. Lawu rising over 10,000 feet, while to the east of it is Mt. Wilis. The Bengawan or Solo river, on which the village of Trinil is situated, issues from the western flanks of Mt. Lawu, while from the eastern and southern flanks of Mt.

[1] " The proto-Australian Fossil Man of Wadjak, Java," *Konin. Akad. van Wetensch. te Amsterdam*, 1920, vol. xxiii. pt. 7.

Wilis rise the upper tributaries of the Brantas river, which, flowing northward, and then eastward through a flat country, reaches the sea at Surabaya. The village of Wadjak will be seen to lie in the upper waters of this river, behind, or to the south of Mt. Wilis. In this locality, 460 feet above the level of the plain which here penetrates between the hills, are clear traces of a former fresh-water lake, now filled up with volcanic dust and ashes. On its limestone shores are terraces which mark
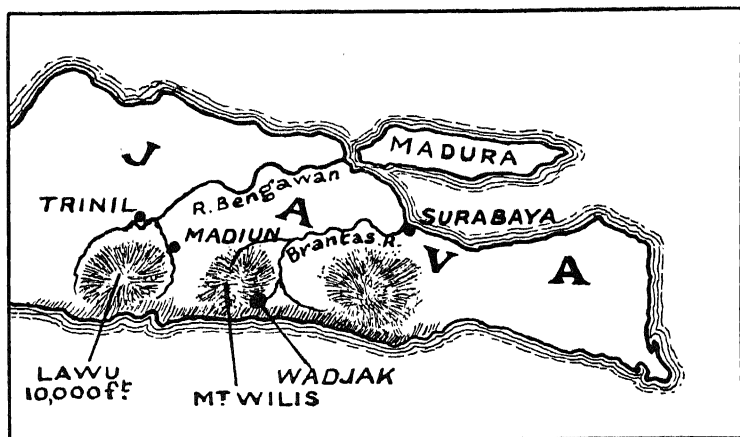
Fig. 154.—Sketch map of the eastern part of Java, showing the sites where the fossil remains of Pithecanthropus (Trinil) and of Wadjak man were found.

former levels of its waters. It was here, in the beginning of 1889, just after Dr Dubois had reached Java, that Mr B. D. van Rietschoten came in search of marble, and while prospecting for suitable stone on the limestone bluffs of the old shore-line, he came across a fossilised human skull in one of the terrace-like deposits. On seeing this skull, Dr Dubois at once recognised that it could not be that of a Malay, the race which has inhabited Java from the dawn of history. In 1890, the year before his first search at Trinil, Dr Dubois visited Wadjak, and at the site where the former discovery was made, found further fossil

bones—parts of a skull, including fragments of the jaws. The bones found first were distinguished as Wadjak I.; the later find as Wadjak II. Dr Dubois believed that Wadjak I. remains were those of a woman, while those of Wadjak II. represented a man. There are grounds for doubting this decision; both may well have been men. However this may be, there is no doubt that the bones were deeply fossilised and lay embedded in the breccia or conglomerate material of the terrace; in the same deposit were fossil bones of animals, but all of these belonged to species still alive in Java. No stone implements were found to help to date the age of the terrace in which these bones had been sealed down, but in Dr Dubois' opinion, they must be regarded as deposits of Pleistocene times.

Another discovery which Dr Dubois made then shows that the limestone cliffs on the shore of the old lake had afforded rock-shelters for prehistoric man. Digging in a terrace which formed a platform at the mouth of a cave, he came across a burial—a skeleton with red ochre still adhering to it. The bones were not fossilised to the degree seen in those of Wadjaks I. and II.; besides the shape of the skull of the red ochre skeleton was different; it had the rounded form seen in Malays. The rock-shelters by the ancient lake at Wadjak had been for long favourite abodes of man.

The fossil bones discovered by Dr Dubois at Wadjak in 1890 belonged to a large-brained type of man. Next year, 1891, at Trinil, only sixty miles distant from Wadjak as the crow flies (fig. 154), he met with the first traces of Pithecanthropus, a being which in point of brain size has scarcely crossed the threshold of humanity. The Wadjak people, after the momentous discovery at Trinil, were relegated to obscurity, and there they remained until 1920. The event which brought them from Dr Dubois' fossil cupboard was the publication of Dr Stewart A. Smith's monograph on the Talgai man—an inhabitant of Australia in Pleistocene times. We may doubt if Dr Dubois' reticence was politic, but we cannot question his honesty;

the Wadjak fossil bones were discovered under the circumstances told by him. There can be no doubt that if, on his return in 1894, he had placed before the anthropologists of the time the ape-like skull from Trinil side by side with the great-brained skulls from Wadjak, both fossilised, both from the same region of Java, he would have given them a meal beyond the powers of their mental digestion. Since then our digestions have grown stronger.

In fig. 155 is given a profile of Wadjak skull I., which Dr Dubois believes to be that of a woman, because the jaws and muscular markings are so much weaker than in the second Wadjak skull. This is not an easy matter to decide, because the degree of sex differentiation varies from race to race and from individual to individual within the same race. In any case Wadjak I. had a skull of remarkable dimensions, overshooting the length of our standard frame of 190 mm. by 10 mm. It is high-vaulted, the roof rising 5 mm. above the standard horizontal and 122 mm. above the ear passages. And it is also wide—145 mm. From such dimensions we are prepared to find a large brain cavity, which Dr Dubois estimates to have had a volume of 1550 c.c., rather less than the dimensions lead one to expect, but this may be accounted for by the thick walls, for the roof has a thickness of 10 mm. In Wadjak II., the brain volume reaches 1650 c.c. How very much these Wadjak people differed from modern Malays will be seen from the following figures. The Wadjak width of skull, 145 mm., is often met with amongst the modern Javanese men, but the Wadjak length, 200 mm., is 25 mm. more than is usually met with amongst them. This ancient people of Java had very long heads, which had steep sides, whereas the Malayan head-form is rounded, the width being 82 or 83 per cent. of the length in place of 72 or 73 per cent. in the Wadjak type. The cranial capacity among Malay men varies between 1350 c.c. and 1450 c.c., whereas in ancient Java there were people with capacities of 1550 c.c. and 1650 c.c.

It is true that the cranial features of the Wadjak people have a certain degree of resemblance to those of the Australian aborigines, but how much they differed,
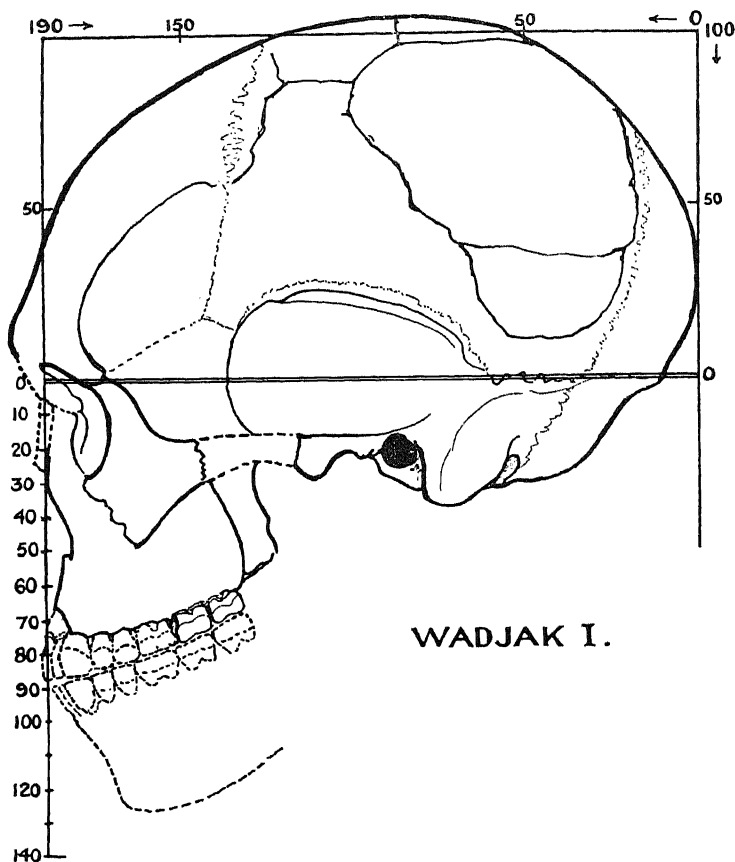
FIG. 155.—Profile of Wadjak skull I., reproducing the outline published by Dr Dubois. The stippled outline of the missing lower jaw represents, on a slightly reduced scale, the corresponding part of the lower jaw of Wadjak II.

particularly in dimensions, will be seen by comparing fig. 155 with fig. 156, and by consulting fig. 161 (p. 454). In fig. 156 there is reproduced the profile of an Australian native woman, showing the characteristics of her race to a somewhat exaggerated degree. The Australian woman's

skull falls short of the standard frame in all its dimensions ; its forehead falling 10 mm. behind the front vertical and the vault 7 mm. short of the 100 mm. level ; its width, too, is only 130 mm. Even the average dimensions of the
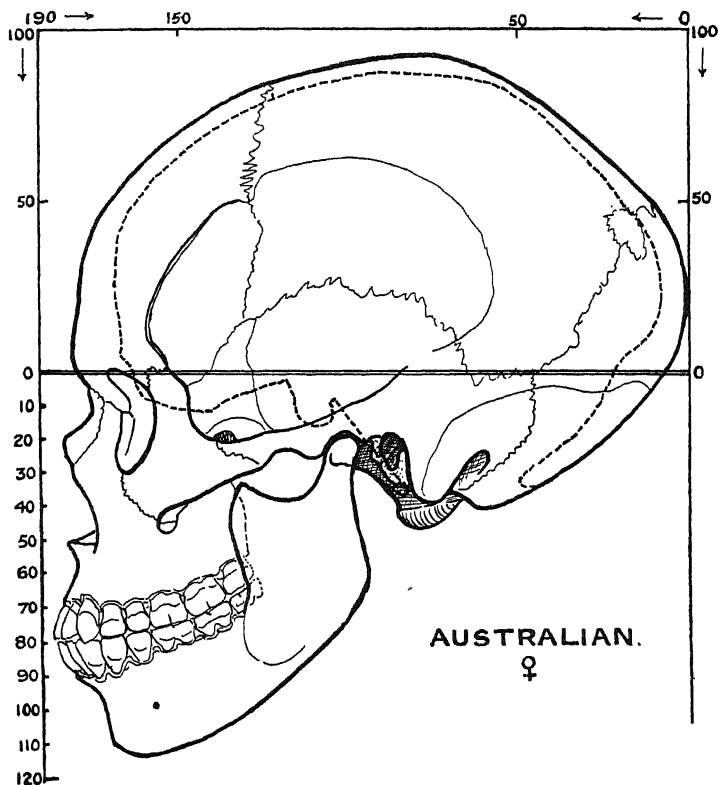
FIG. 156.—The profile of the skull of an aboriginal woman of Australia, for comparison with the Wadjak type, given in fig. 155.

skulls of aboriginal males fall far short of our standard frame. These dimensions, as determined by Professor R. J. Berry and D. Robertson for male Australian skulls, are : length, 183·5 mm. ; width, 130·6 mm. ; in female skulls the length is less by 7·4 mm. and the width by 4·6 mm. If the aborigines of Australia have sprung from the Wadjak type, as Dr Dubois is inclined to suppose,

then evolution has taken a retrograde course, for the average cranial capacity of the male Australian is 1287 c.c.—300 c.c. less than in the Pleistocene people of Java.[1]

In spite of their large skulls and brains they were a primitive people who lived in the rock-shelters of Wadjak. This is made clear by the size and strength of their jaws. In fig. 157, the palate of Wadjak II. is set side by side with that of Rhodesian man. Both have the same great area, 41·00 cm.[2], and the same horseshoe shape; both have the same massive molar teeth. The width between the outer borders of the second molars of Wadjak II. is 81 mm. —3 mm. more than the Rhodesian palate, 14 mm. more than the average Australian palate, and 19 mm. more than the English palate. On the other hand, it will be observed that the incisor, canine, and premolar teeth are less robust in the Wadjak skull than in the Rhodesian, and so also is the part of the palate on which these teeth are set. This is the part of the palate which carries the milk teeth in childhood, and it is remarkable that retrogression should have fallen first and most on this area. The bicanine width in the Rhodesian palate is 53 mm., in Wadjak II. 48 mm.; in Europeans this diameter, the muzzle width, usually falls to 40 mm. or less. In the Talgai skull, as we shall see, it rose to the record height, for a human palate, of 59 mm. The palatal area is 35·00 cm.[2] in Wadjak I., which is 4·00 cm.[2] more than is usual in Australian males and 10·00 cm.[2] more than is usual in the mouths of British males.

In the width of the ascending ramus which represents the muscular lever of the lower jaw, Wadjak II. falls only 5 mm. short of the dimension reached in the Heidelberg mandible. Yet, as may be seen in fig. 157, the alveolar sockets in which the Rhodesian teeth were set are much more strongly formed than in the Wadjak palate. Nevertheless the molar teeth of these two men, separated as their homes were by the whole width of the Indian Ocean, are almost identical. The upper Wadjak molars are wide,

[1] See p. 451.

varying in their labio-lingual diameters from 12·5 to
13·5 mm.; the combined length of the three molar teeth
is 34 mm., the same as in Rhodesian man, whereas in
Europeans the molar length usually falls below 30 mm.
In the lower jaw the combined molar length of Wadjak II.
was 36·7 mm.[1]

The teeth and jaws of Wadjak man were strong and
massive, but their forward projection—their prognathism
—was masked, as in Rhodesian man, by an equally forward
growth of the forehead and upper face. In Australian
natives, on the other hand, prognathism is usually very
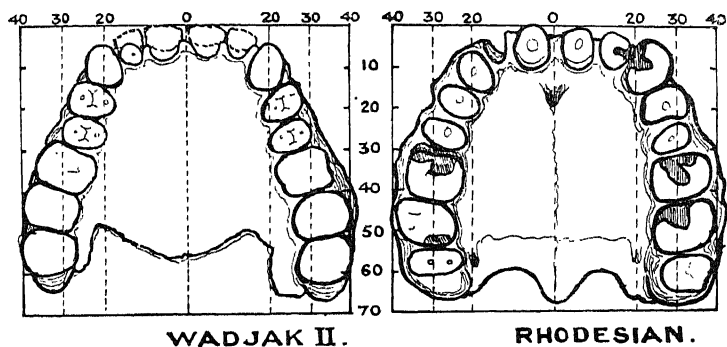
FIG. 157.—The palate of Wadjak II., set beside that of
Rhodesian man.

evident (fig. 156). The Wadjak face, compared with
the Rhodesian, is moderate in its dimensions; the great
supra-orbital torus is replaced by pronounced eyebrow
ridges, of a size and form such as are to be seen in the
skulls of Australian natives; the Wadjak orbits and cheek
bones are Australian in form and dimensions.

In tracing the relationship of races of mankind, both
living and extinct, the nose is a helpful guide. Dr Dubois
has noted that the nasal bones which form the bridge and
ridge of the nose were small in the Wadjak skulls, and
that the nasal bridge was low and flat. The nasal aper-
ture, however, was wide, namely 30 mm. in Wadjak I.

[1] For full details, see Dr Dubois' original paper, the reference to which
is given on p. 438.

and 32 mm. in Wadjak II.; in the Rhodesian skull the width of this aperture was 31 mm.; in Neanderthal man, 35 mm.; in Europeans, 24 or 25 mm. is a common width. Now, in only two living human stocks do we find a wide nasal aperture combined with a reduction and flattening of the bones forming the bridge and ridge of the nose—in the negro stock and in the aborigines of Australia. In Mongolian peoples, the nasal bones are small but the nose is not wide. In this feature the Wadjak race is linked to the negro and original Australian stocks. In Rhodesian man, the bridge of the nose, although not raised, has nasal bones which recall the long spatulate form met with in the gorilla.

There is a remarkable parallel between the ancient types of man discovered in Java and South Africa. Rhodesian man, small of brain and primitive in structure, has, as his successor, in later Pleistocene times, a big-brained type—Boskop man. The homeland of Pithecanthropus became in later days the dwelling-place of the big-headed Wadjak type. The Wadjak type and Pithecanthropus lie far apart in man's family tree (see fig. 163). There it will be seen that I have placed Wadjak man as an offshoot from the stem which afterwards diverged into Australian and negro types. I have placed him thus because of his many resemblances to the older and more primitive Rhodesian man on the one hand, and to the Australoid type on the other. The Wadjak type is one which seems to bridge the gap which lies between Rhodesian man and the Australian aborigine. And yet in size of brain he differs from both of these and approaches or surpasses the big-brained types of Pleistocene Europe—the Cromagnon and Neanderthal. Of this matter I shall offer an explanation presently (see p. 605). Big-brained Wadjak man is an extinct type; nowhere can we trace his descendants among living races.

We are now to leave Java and make our way to the Northern Territory of Australia, along the chain of islands which stretch eastwards from Java, taking us to the Island of Timor, 900 miles forward on our journey.

We carry with us, as a working hypothesis, the opinion expressed by Dr Dubois that the extinct Wadjak people represent the type which reached Australia in Pleistocene times and which in course of evolution became transformed into the aborigine of that continent. The route we are following is the one which these pioneer settlers of Australia must have taken. When we reach Timor we find a sea voyage of some 400 miles is necessary to reach the nearest part of the coast of Australia, the part which lies in the neighbourhood of Port Darwin. We have a right to think that Australia was more accessible to the Pleistocene pioneers than we now find it to be. At an early part of this period, and perhaps at a later, the great islands of the Malay Archipelago were linked to the continent of Asia—as far to the east as the deep-sea line drawn by Russell Wallace. An elevation of 600 feet in the level of the land will join Java to the Malay peninsula and at the same time reduce the sea voyage from Timor to Australia to about 100 miles, but much less than this it could not have been. Somehow early man crossed this wide stretch of sea and took with him his wife and dog for company.[1] Such a statement comes as a shock to those of us who have grown up in the belief that man discovered the art of seafaring only five thousand years ago—for here we are supposing that the primitive settlers of Australia had conquered the art fifty thousand years ago.

Those who have had experience of the aridity and heat of Northern Australia, and of the great deserts of its interior, may think there was little to tempt early man to make so arduous a voyage. In Pleistocene times, however, Australia was well watered and fertile ; the channels of ancient rivers can still be traced across her sandy wastes. Australia, like other countries which lie within the desert belts of the world, had, and has, her climatic cycles. These and their bearing on the evolution and spread of human races have been elucidated by

[1] See an article by Professor F. Wood Jones, " The Status of the Dingo," *Trans. Roy. Soc. of South Australia*, 1921, vol. xlv. p. 254.

Professor Griffith Taylor [1] of the University of Sydney, to which city we are bound.

On 21st August 1914, when the British Association met in Sydney, two members of the teaching staff of its University, Sir T. W. Edgeworth David, Professor of Geology, and Professor J. T. Wilson, who then occupied its chair of anatomy, had a surprise in store for the members of the Anthropological section. It was a fossil human skull, still encrusted in a stony matrix, which had just emerged from the retirement of a cupboard, where it had lain for thirty years, for it had been found in 1884. That it was of a Pleistocene age was proved by Sir Edgeworth David, who succeeded in tracing it to a deposit which contains extinct species of Australian marsupials, on the station or farm of Talgai, situated on the Darling Downs in the southern part of Queensland. He had the good fortune to meet the discoverer, one who had been a " fencer " on Talgai Station in his younger days. This man had gathered the skull from the bed of a creek, after a flood which had torn open its banks.

The fossil skull shown to the British Association at the Sydney Meeting in 1914 was the first definite evidence of man's existence on the continent of Australia in Pleistocene times. This discovery certainly did not surprise Mr R. Etheridge, junr., of the Sydney Museum, who had put on record, as early as 1890, that a human molar and remains of the dingo had been found as component parts of a cave deposit which also contained the fossil bones of extinct marsupials. This discovery was made in Wellington Caves, New South Wales.

When the Sydney Meeting of the British Association broke up, the Talgai skull was entrusted to Dr Stewart Arthur Smith for investigation and description. Although, as we shall see, the skull was deformed and crushed by the weight of overlying strata, yet Dr Smith

[1] " Climate Cycles and Evolution," *Geograph. Rev.*, 1919, vol. viii. p. 289. " Evolution and Distribution of Race, Culture, and Language," *ibid.*, 1921, vol. ii. p. 54.

succeeded in unravelling its original characteristics, and his monograph,[1] which was communicated to the Royal Society of London by his distinguished brother, Professor G. Elliot Smith, supplies professional anthropologists with the facts which they always stand in need of, but do not always succeed in obtaining, from original descriptions. It was, as we have seen, the publication of Dr Smith's paper which induced Dr Dubois to announce his discovery of a " proto-Australian " type in Java.

The reader will see from the sketch map in fig. 158 that Talgai, situated on the Dalrymple Creek, a tributary of the
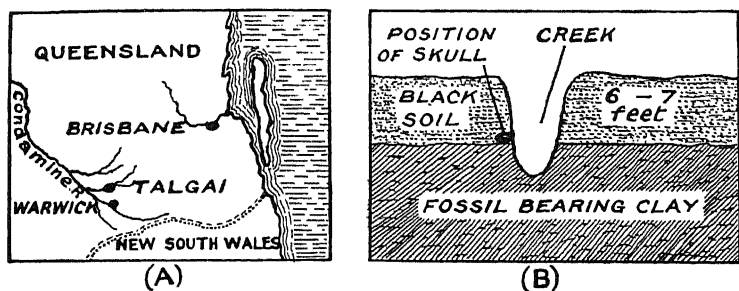
FIG. 158.—A. A sketch map of Southern Queensland, showing the position of Talgai.   B. A section of the strata near the site at which the skull was found.   (After Stewart Smith.)

Condamine river, is eighty miles distant from Brisbane. The section given in fig. 158, B, shows that near the place where the skull was found there is a depth of 6 or 7 feet of black soil.   Under this comes the fossil-bearing deposit, a red-brown clay, containing nodules of chalk.   This stratum had been laid down by streams which flowed from the Darling Downs in Pleistocene times.   The Talgai skull has the same colour and the same state of fossilisation as the bones of extinct marsupials—of Diprotodon, Notelephas, Nototherium—which are also found in this Pleistocene formation.   One may safely infer that this Talgai deposit is older than those which

[1] Dr Stewart Arthur Smith, " The Human Fossil Skull found at Talgai, Queensland," *Phil. Trans.* (ser. B), 1918, vol. ccviii. p. 351.

yielded the Wadjak and Boskop remains; most probably it outdates the cave strata in which are found typical representatives of Neanderthal man.

Dr Stewart Smith found that the skull was that of a lad between fourteen and sixteen years of age, for his
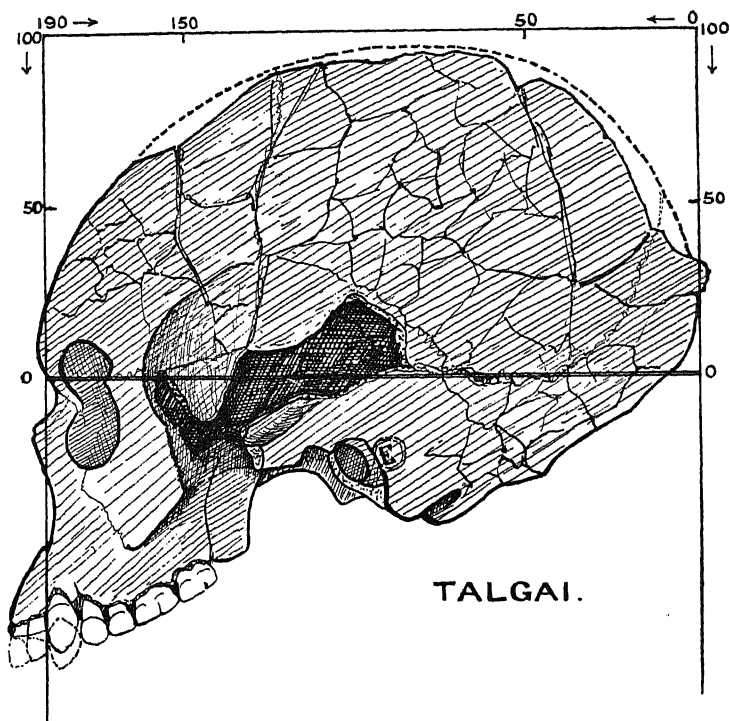
FIG. 159.—Profile of the Talgai skull, drawn from a cast of the skull, with certain details introduced from Dr Stewart Smith's figures.

wisdom teeth, although the crowns were formed, were still buried in the jaw. In fig. 159 the skull is shown in profile; it has been so much crushed that no exact estimate can be given of its original dimensions, but a comparison between this outline and that of the aborigine's skull reproduced in fig. 156 (p. 443) leaves no doubt that this ancient lad from the Darling Downs had the essential cranial characters of the Australian aborigine,

and may be looked upon as a true and early representative of the Australian type. Dr Smith estimates the original length of the skull to have been 192 mm., its width 141 mm., the height of the roof above the ear passages 105 mm., and the cranial capacity 1300 c.c. All of these estimates are rather below than above the mark. Yet all of them, save that of auricular height, which I believe to have been 112 mm., are much above the average dimensions of the skulls of modern Australian aborigines. The forehead in the region of the eyebrows, and at the glabella over the root of the nose, is very thick for the skull of a lad of fifteen years of age—at the glabella the skull wall measured 16 mm. The vault is 7 mm. thick, the occipital bone at the neck, 9 mm. One estimates that of the total length of his skull, bony walls made up 13 per cent.; this amount is 5 per cent. more than is usual in Europeans, and 5 per cent. less than in Rhodesian man. Such a proportion of the bony wall to the total length is, however, frequently surpassed in the skulls of Australian aborigines.

If we turn from the cranial features, about which only general statements can be made, to the characters of the face and palate, where precise estimates can be given, we find we have, in this Talgai lad, a very primitive human type. The size and shape of his palate is represented diagrammatically in fig. 160; side by side with it is placed a drawing of a modern Australian palate of large size. In size and shape the Talgai palate is the most anthropoid ever seen in a human skull, but it is probable that in these respects it stands below the palate of Piltdown man. When the crowns of the uncut wisdom molars are raised into place, as in fig. 160, the length of the palate must be estimated at 70 mm., 3 mm. more than is given by Dr Smith, and 6 or 7 mm. more than in any other known human palate. As in anthropoid palates, the width—66·5 mm.—is less than the length, in this respect differing from the horseshoe palate of the Rhodesian, Wadjak, and Neanderthal skulls. Its most anthropoid feature lies in its " muzzle-width "—its

bicanine diameter—which amounts to 59 mm. The greatest width of the palate of the male gorilla lies across its canine part ; in the Talgai palate there is an approach to this condition, the bicanine width being 88 per cent. of the bimolar width, whereas in Rhodesian man this relationship falls to 68 per cent., while in the palates of modern Englishmen it sinks usually to 62 per cent., and often lower. In that part of the palate which carries the incisor, canine and premolar teeth—the part which represents the "milk" palate of childhood—the Talgai

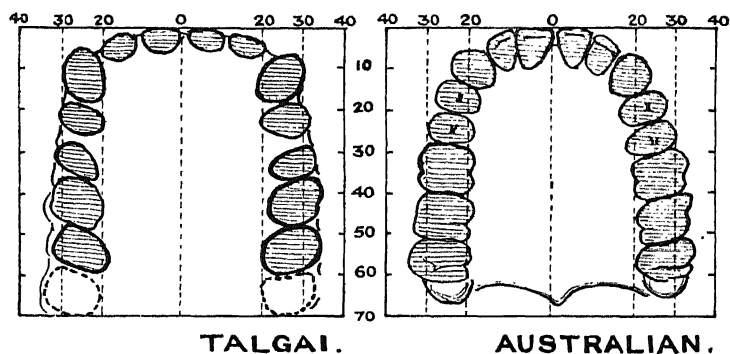TALGAI.   AUSTRALIAN.

Fig. 160.—An outline of the palate of the Talgai skull. The third molars are represented as if they had erupted and were in use. (After Stewart Smith.) The adjoining palate, of exceptional size, is that of an Australian skull in the R.C.S. Museum.

lad retained most primitive features and dimensions, whereas in the Wadjak man it is just this part which is small when compared with the molar part. In its total area, 40·00 cm.^{2}, the palate of the Talgai people, although differing in shape, falls very little short of the size of the Wadjak and Rhodesian specimens, namely, 41·00 cm.^{2}. The average palatal area of the Australian male is 31·60 cm.^{2} ; in the large palate drawn in fig. 160 the area rose to 34·60 cm.^{2}.[1]

The molar teeth, which have so often to guide us in settling the relationships of extinct races, are, in the Talgai lad, very similar in form and dimensions to those

[1] For comparative measurements, see p. 659.

of the Rhodesian and Wadjak men, and yet their palates were quite different in shape. The Rhodesian and Wadjak palates have the horseshoe or human shape, while the Talgai lad had one with almost parallel sides— of the anthropoid type. The Talgai molars have a great width, varying from 13 mm. to 13·5 mm.; their combined length is 34·9 mm., slightly more than in the two rival types of men just mentioned. Dr Smith has rightly emphasised the prominence, shape, and size of the Talgai canine teeth. When the left canine is brought into its proper position (fig. 159) it passes beyond the level of its neighbours to a greater extent than in other races of the " modern " type. But in form the canines are altogether human, having none of the anthropoid traits preserved in the canine tooth of Piltdown man.

When we come to settle the position of this Australian Pleistocene type of man in the scheme of human evolution, our task is not a difficult one. His place, as shown in fig. 263, lies in the Australian stem ; he is ancestral to the modern aborigine ; the characters of his forehead, orbits, nose, and face, and shape of skull, as far as this can be made out, are Australoid, and under this term is included the head-form of the extinct Tasmanians. For undoubtedly the Tasmanian native, in spite of a preponderance of negroid traits, including his woolly hair, came of the same stock as the Australian aborigines. They are cousin peoples of the same stock. So alike are they in their cranial characters that it is difficult to separate Tasmanian from Australian skulls in a mixed collection. It is only in those cases where racial traits are pronounced that we can distinguish the one skull from the other. In a large proportion of cases, certainly in fifty out of every hundred skulls, the racial characters are equivocal. Hence in my schematic tree I have brought the Tasmanian and Australian branches from a common stem and placed the Talgai type at the base of this stem (fig. 263). We have to keep in mind that negroid and Australoid types have a common ancestry and that the

Tasmanian and other Pacific peoples have preserved their negroid inheritance to a higher degree than has been done by the Australian natives.
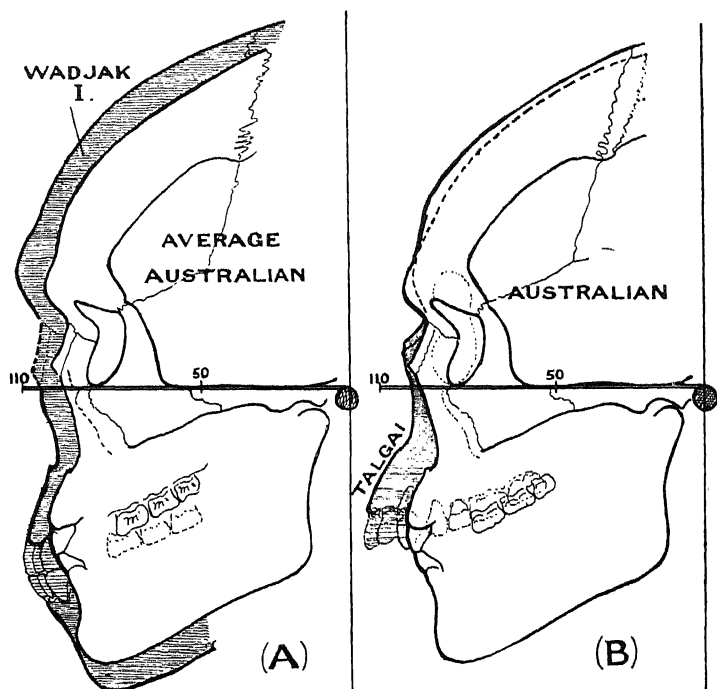

FIG. 161.—A. Profile of a composite Australian face, based on measurements made on the skulls of ten male aborigines of Australia. This profile is oriented on the Frankfort plane—which passes from the sill of the orbit to the upper margin of the ear passage. The facial outline of Wadjak I. is placed on this plane, its ear passage coinciding with that of the other figure. B. The same Australian profile with the profile of the Talgai lad placed as described above. In this comparison the true position of the ear passage of the Talgai skull has been fixed as shown in fig. 159 (E), behind the site in the fossil cast, for the temporal bone has been dislocated in a forward direction by earth pressure.

Dr Eugene Dubois regards the Wadjak type of Java as proto-Australian. Both in a geological, as well as in an anatomical, scale of reckoning, we may safely regard the Talgai as an older human type than the Wadjak. The diagram given in fig. 161, A, will help the reader to

form an opinion as to the degree of resemblance between these two types.

In this figure there is represented a composite profile of the male Australian—founded on the average dimensions of ten skulls; it is oriented on the Frankfort plane, as described in the legend to the illustration. Behind this composite profile is placed the profile of Wadjak I., on the same plane with ear-hole superimposed on ear-hole. It is at once seen that in all dimensions the Wadjak overwhelms the modern Australian type. To make the Wadjak type into the Australian needs an extensive reduction in all parts, and when this is done, there remain so many points of difference that we cannot regard their relationship as more than a cousinship. The case is quite different as regards the Talgai type. As is shown in fig. 161, B, we have only to suppose that there has been a reduction of jaw development to bring the Talgai profile into close agreement with the modern Australian profile. Proto-Australian is not the right name for the Wadjak man; he is related to the Talgai or Australian type and he is related to the Rhodesian type, but he is later and higher than either of them.

Our final conclusion is that the Talgai skull represents the ancestral Australoid type, and is the earliest form of true *Homo sapiens*—man of the modern type—yet discovered. This conclusion raises an evolutionary problem of the utmost importance. We are presuming that reduction of jaw has taken place in the evolution of the modern Australian type; we have made the same statement as regards reduction of jaws in European, African, and Neanderthal races. We have presumed that an evolutionary process, exactly of the same nature, has worked independently in all four types, and that therefore mere size of jaw, or shape of jaw, may be no guide to racial affinity.

In a former page (p. 407) it was pointed out that in the fashioning of the sill of the nose, the same change has taken place in diverse races of mankind. We find that the external ear of the Bushman and

that of the orang have undergone great reduction and that these structures have taken on a superficial likeness to each other. We find that the eyebrow torus of the anthropoid ape has persisted in Neanderthal man and Rhodesian man, but it has been replaced on the forehead of Wadjak man and other Australoid races by eyebrow ridges of the modern kind. In many monkeys we find the same kind of eyebrow ridges as in modern races of mankind.

Huxley had noticed, and so have many other students of evolutionary processes, that the same new feature may appear independently in several races, but on inquiry it will be found that they are races which there is good reason to think have descended from a common ancestor. Yet this ancestor may show no sign or trace of the new feature. We have in such cases to suppose that an evolutionary bias may be latent in a stock, a bias which will manifest itself by structural alterations in some descendants and not in others. It is in this way that I would explain the growth of brain in Neanderthal man and in some races of modern men. On the same principle I would explain jaw and tooth reduction. The increase of brain and the retrogression of jaw have taken place apparently independently in diverse races, but in all cases these changes appear to be traceable to a common source—a bias inherent and latent in the ancestral stock from which all of these races have sprung. We cannot explain the facts revealed by this study of ancient man unless we accept the principle just enunciated (see also p. 728).

In bringing this chapter to a close, and before carrying our search to another continent, it may be well to emphasise the importance of the Talgai discovery. It is important because it was made in the isolated continent of Australia. In this continent has come down to us, much changed by specialisation of a superficial nature, mammals which are really living fossils, representatives of a very ancient stage in mammalian evolution. In the same way this continent has preserved for us a very

ancient type of man.   It is true the jaws of this ancient type have grown smaller in his descendants, but they have kept his essential characteristics.   More than any other man, the aborigine of Australia and Tasmania seems to have conserved the qualities of the stock which gave rise to all modern breeds.   We may look upon him as the best living representative of Pleistocene man.

CHAPTER XXIV

THE ANTIQUITY OF MAN IN NORTH AMERICA

Before setting out to seek for evidence of man's antiquity in the " New " World, it may be well to sum up the conclusions which have been forced upon us by evidence gathered on the continents of the " Old " World. From earliest Pleistocene times onward Europe was inhabited ; we know three types of ancient Europeans—the Piltdown type, which will be described in a future chapter, the Neanderthal type, and the modern type. The last named was certainly in Europe in later phases of the Ice age, perhaps in the earlier, if the evidence of Galley Hill man will hold. We have not found, however, the immediate ancestor of modern man, although there is reason to suspect that his cradle-land lies in the north of Africa or the south-west of Asia. That this type is old we know from the primitive example found in a Pleistocene deposit at Talgai, Queensland. The discovery at Talgai is sufficient to convince us that modern man, even in his primitive days, had a power of penetration, for to reach the isolated continent of Australia in Pleistocene times demanded both daring and resource.

Then in Africa, south of the Equator, we have met with strange Pleistocene types—the Rhodesian and Boskop. Java, we found, was inhabited before the end of the Pliocene period by beings who, however poorly endowed with brain, were already in possession of human lower limbs quite sufficient to carry their bodies as far as habitable lands extended. Later, there were big-brained men in Java. If the lands of the New World

remained untrodden by the foot of man throughout Pleistocene times, it was not because the Old World was then uninhabited.

Nor was access to the New World lacking; geologists have abundant evidence to prove that, at various phases of both Pliocene and Pleistocene periods, Siberia and Alaska enjoyed a temperate climate and were united by a wide land-bridge across which American and Asiatic animals could come and go. The floor of the sea south of Bering Strait is shallow; an elevation of 600 feet will give a wide land-bridge. If Pleistocene man could make his way to Australia, he could certainly have reached America from Siberia. That he was in Siberia at an early date is also certain, for, as we have seen, the ancient gravel deposits of the Yenesei valley contain his stone implements. As was mentioned previously, human remains have been found deep in a Pleistocene deposit in the province of Kansu, on the western frontier of China. It is, then, quite possible that some of the early types of Old World man may have strayed into America across the land-bridge. As yet, however, we have found none of them; all the human remains so far discovered in America are those of men of the modern type. Other and more primitive types may yet be discovered; in the meantime we must remember that such remains, although modern in type, may be of great antiquity; age must be determined, not on type, but on geological evidence.

Anthropologists are agreed that the pre-Columbian population of America did enter America from the Asiatic side.[1] They are also agreed that the native peoples of America, from Hudson Bay to Cape Horn, are descended from the same human stock as has populated the eastern regions of Asia and many of the islands of the Pacific. The American Indian, in all his varieties, is a descendant from a primitive Mongolian type of man.[2] If, however,

[1] See an excellent summary of Dr Aleš Hrdlička, " The Derivation and Probable Place of Origin of the North American Indian," *Proc. Internat. Congress of Americanists*, London, 1912, p. 57.

[2] See p. 718.

we ask : How long ago is it since the Mongolian type of modern man was evolved ? When did the American branch of this stock enter the New World ? we receive very uncertain answers from those who have studied the early population of America. At present, only a tentative answer can be returned to the questions just asked, but to those who watch the vigour and success with which the thriving anthropological schools of America are pursuing the study of ancient races and ancient civilisations, it is quite apparent that a full answer will be given us at no distant date.

There is no need here to give a general review of the evidence relating to the antiquity of man in North America. This has been excellently done in the publications issued by the Bureau of American Ethnology,[1] and by Dr G. Frederick Wright in his latest work, *The Origin and Antiquity of Man*.[2] The investigations of Dr Wright, and of other American geologists who have studied the physical condition of North America during the Pleistocene period, are of the greatest service to anyone in search of the remains of ancient man. They have shown us that the variations of climate in North America during the Pleistocene period were very similar to those of Europe. There were the same southward extensions of the ice-sheet in the colder phases ; the same northward retreats in the interglacial or milder intervals.

It is beyond the scope of this work to give a systematic description of the ancient remains of man discovered in America. All we propose to do here is to make a rapid journey across North America from east to west,

[1] See *Bulletins of Bureau of American Ethnology*, Smithsonian Institution, Washington, particularly No. 33 : "Skeletal Remains suggesting or attributed to Early Man in North America," by Dr Aleš Hrdlička, 1907.

[2] Dr Wright died in 1921, aged eighty-three. He spent a large part of his life in studying the glacial deposits of North America and became convinced that the older geologists had greatly overestimated the duration of the Ice age. The estimate he formed of the time which has elapsed since the Ice age came to an end agrees with that of Baron de Geer, namely, about ten thousand years.

citing the evidence of the more important discoveries of the remains of ancient man as we go. The line of our journey follows the zone occupied by the fringe of the ice-sheet during the period of maximum glaciation. In America, as in Europe, the glacial deposits are the treasure-houses of the student of prehistory.

We shall commence our journey some fifty miles to the south of New York—at Trenton City, situated at the head of Delaware Bay, in the State of New Jersey. The great expanse of gravel on which Trenton has been built was deposited by the Delaware during the Ice age. This gravel has yielded the kind of evidence of which we are in search—the stone implements and the fossil remains of ancient man. During the most severe of the glacial phases the edge of the ice-sheet lay only sixty-five miles to the north of Trenton. In the valley of the Delaware river the deposits laid down along the southern edge of the ice-sheet can still be seen. The marginal deposit of the ice-sheet—the moraine—is connected with the gravel bed on which Trenton is built by a terrace which descends on each side of the valley of the Delaware river. There can thus be no doubt that the Trenton gravels are deposits of the Ice age. They were laid down at the mouth of the river at sea-level. Since their deposition the land has risen, so that now the ancient gravel delta is 50 feet above the present level of the sea.

The story of the discovery of traces of early man in the Trenton gravels recalls early incidents in the valley of the Somme. The place of Boucher de Perthes is taken by Dr C. C. Abbott. In 1875 the Pennsylvania Railroad had opened a pit in the gravel bed near Dr Abbott's house. Dr Abbott watched the pit from day to day, and ultimately found numerous examples of roughly chipped stone implements, recalling the palæoliths which are contained in the valley terraces of Europe. They occurred at all levels of the gravel, and in strata which had never been disturbed since the date of deposition. Dr Abbott's discovery was received

with the same degree of scepticism as had been extended to the earlier efforts of Boucher de Perthes in France. Fortunately his investigations attracted the attention of Professor F. W. Putnam of the Peabody Museum of Harvard University. Under his direction Mr Ernest Volk [1] commenced a long series of accurate investigations which proved the truth of Dr Abbott's statements.[2] Under the surface layer of black soil lay a stratum of yellow sand and loam, regarded by American geologists as a post-glacial deposit. In this post-glacial stratum there occurred stone implements worked in basalt and argillite of a late Palæolithic type, while in the black soil were found traces of Indian occupation—hearths, Indian stone implements, and Indian burials. In the underlying beds of gravel, which, as already mentioned, are glacial or Pleistocene deposits, traces of man were also found in the form of rudely shaped implements of stone.

Remains of the men who actually shaped those implements were first discovered in December 1899 by Mr Volk. A "railroad cut" had laid open a section of the gravel in the suburbs of Trenton. On the exposed face, within a stratum of sand and clay $7\frac{1}{2}$ feet below the surface, Mr Volk found part of the shaft of a human thigh bone. He recorded his discovery by photographing the fragment in place before removing it from the bank. Parts of the bone of a human skull were also found. In the opinion of Mr Volk and Dr Hrdlička both specimens—the fragment of thigh bone and fragment of skull—show certain incised markings apparently made by ancient man.

Through the kindness of Dr Peabody, the writer obtained accurate casts of these two specimens found in

[1] These two pioneers, Dr Abbott and Mr Volk, died in the same year —1919.
[2] "The Archæology of the Delaware Valley," by Ernest Volk, *Papers of the Peabody Museum of American Natural History and Ethnology*, Harvard University, 1911, vol. v. See also note by Dr C. Peabody, *Proc. Internat. Congress of Americanists*, London, 1912, p. 3.

the Trenton gravels for the museum of the Royal College of Surgeons, England. Only about one-third of the upper part of the shaft of the left thigh bone is represented, and about an equal proportion of the left parietal bone of the skull (fig. 163). In the extensive collection of skulls and skeletons in the museum of the Royal College of Surgeons—representing all races—the writer could find exact duplicates of those two fragments in only one skeleton, that of an Indian from an ancient cemetery in the State of Illinois.[1] On the inner aspect of the cranial fragment the impressions of the convolutions of the brain are most sharply preserved. The main fissure of the brain—the fissure of Sylvius—is clearly
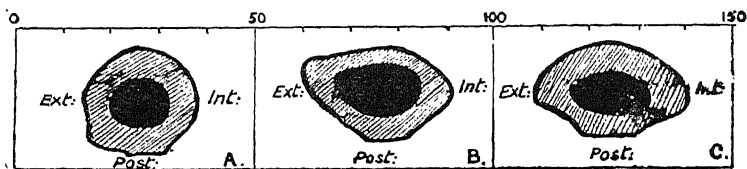
FIG. 162.—Section across the upper third of Trenton femur (B) compared with corresponding sections of a modern European femur (A) and that of a Neolithic European (C).

represented, and the size and shape of the important convolutions which surround the hinder end of the fissure can be studied as clearly as on the brain itself. In size and shape the convolutions do not differ from those of the brain of modern man. The cranial fragment is clearly part of a parietal bone, which in size and shape agrees with the corresponding bone in a well-developed cranium of an American Indian. The thigh bone is flattened from back to front in its upper third—a feature seen in American Indians, and also in many modern and ancient primitive races (fig. 162). No one can study the Trenton fragments and remain unconvinced that the man who lived in the valley of the Delaware when the Trenton gravels were being deposited was a man of the modern

[1] Dr Hrdlička has published an account of the osteology of the Delaware Indians. Bureau of American Ethnology (Smithsonian Institution), *Bulletin* No. 62, 1916.

type, and almost certainly of the Indian race. In size of brain and in posture of body he did not differ from the men who succeeded him in post-glacial times.

The antiquity of modern man in the Delaware valley thus turns on the age of the Trenton gravels. They are admitted by all geologists to belong to the glacial period;
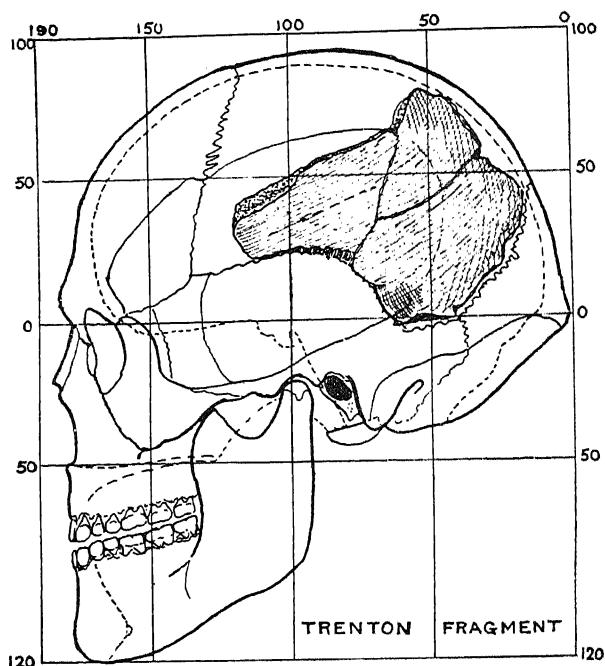

FIG. 163.—Drawing of a skull of an American Indian on which the cranial fragment found at Trenton is represented.

but to what point of the glacial period? We may regard these gravels as deposits of the last glaciation in America, the glaciation to which American geologists give the name " Wisconsin," because its deposits are particularly abundant in the State of that name. If the glaciations of Europe and North America occurred at the same time—which is an unproved, but not improbable supposition—then the last or " Wisconsin " phase of the one and the last or " Würmian " phase of the other would

correspond. We have seen that before the end of the last glacial phase in Europe, mankind in the eastern hemisphere had entered on the Aurignacian stage of culture, and, in structure of body, belonged to the modern type. The introduction of the Aurignacian culture in Europe appears to have taken place about fifteen thousand years ago—an estimate which must be regarded as merely tentative. It does seem possible, then, that the ancient men of Trenton were living in the Delaware valley when the Cromagnon race inhabited the rock-shelters along the valley of the Dordogne.

The discovery at Trenton has a very direct bearing on the antiquity of men of the modern type. Let us look more closely at its significance. It is a guarantee that before the last period of glaciation modern man, in the form of that highly evolved race—the American Indian— was living on the eastern seaboard of North America. This race, as we have seen, represents a branch of the Mongolian stock. It is therefore plain that, long before the last period of glaciation, the Asiatic ancestry of the American Indian must have been in existence. We obtain, by researches carried out in Europe, a glimpse of Palæolithic man in the western part of the Old World ; the discovery at Trenton gives us, indirectly, the information we stood in need of, namely, that, at an equally early part of the Palæolithic period, men of the modern type were in existence in the eastern part of the Old World. To account for modern man in Europe, in Asia, in America, long before the close of the Ice age, we must assign his origin and evolution to a very remote period.

Having thus obtained reliable evidence of the great antiquity of man on the eastern seaboard, we pass to the Central States, approaching them from the south, along the valley of the Mississippi. Our first stopping-place is Natchez, on the eastern bank of the river, and about 200 miles above the delta. Here, in 1846, came Sir Charles Lyell in search of evidence regarding man's antiquity. On the eastern side of the valley at Natchez

rises a high terrace of yellow loam or loess, a deposit formed by floods during the latter part of the glacial period. At the time of Lyell's visit part of a human pelvis had been discovered in this ancient deposit. The site of the discovery was a ravine cut in the loess deposit by a tributary stream. Lyell visited the ravine to examine the details of the discovery for himself.

" I satisfied myself," he writes,[1] " that the ravine had been considerably enlarged and lengthened a short time before my visit. From a clayey deposit, immediately under the yellow loam, bones of the mastodon and the megalonyx (an extinct form of sloth) had been detached and fallen to the bottom of the cliff. Mingled with the rest, the pelvic bone (*os innominatum*) of a man was obtained by Dr Dickeson of Natchez, in whose collection I saw it. It appeared to be quite in the *same state of preservation, and was of the same black colour* as the other fossils, and was believed to have come from a depth of about 30 feet from the surface."

The pelvic bone thus brought to light differs in no respect from that of modern man : it differs materially from that of Neanderthal man. Professor Joseph Leidy, an expert palæontologist of the highest rank, examined the specimen again in 1889,[2] and observed that the degree of fossilisation was exactly the same as that of the bones of extinct mammals which were found with it, and that " it differs in no respect from an ordinary average specimen of the corresponding recent bone of man."

Lyell was afraid to use the bone found at Natchez as evidence ; it seemed to him suggestive of too great an antiquity for man. He had calculated that the formation of the delta of the Mississippi had occupied a period of one hundred thousand years, and he recognised that the loam or loess lying over the fossil bones was older than the delta. The plateau at Natchez was, in his opinion, almost as old as the classical 100-foot terrace at Abbeville. He, therefore, was inclined to regard the pelvic bone as

[1] *Antiquity of Man*, 1st edition, 1863, p. 202.
[2] See Dr Hrdlička's account ; reference on p. 460.

having slipped from a recent Indian grave in the loess deposit, and subsequently had become mingled with the bones of extinct animals. " No doubt," he adds, " had the pelvic bone belonged to any recent mammifer other than man, such a theory would never have been resorted to ; but so long as we have only one isolated case, and one without the testimony of a geologist who was present to behold the bone, while still engaged in the matrix, and to extract it with his own hands, it is allowable to suspend our judgment as to the high antiquity of the fossil." After what we have seen at Trenton, the plea of " isolation " cannot any more be urged. The legitimate inference must be drawn, be the loess of the Mississippi valley what age it may, that man was living in the Mississippi valley during its deposition.

Before passing on our journey, it will be convenient to glance at a discovery similar to that at Natchez which was made recently on the east coast of Florida, at Vero, a small town seventy miles to the north of Palm Beach. In 1916 a sewer was being dug in the low flat land near the coast when the following strata were cut through : (1) 2 feet of soil containing shells ; (2) a stratum 1 to 3 feet in thickness made up of a hard sandy marl ; (3) a stratum containing the fossil bones of Pleistocene animals— mammoth, mastodon, horse, and sloth. In this Pleistocene deposit were found parts of two human skeletons, flints fashioned in the Indian manner, and also shards of pottery. Two most competent geologists, Dr E. H. Sellards and Dr O. P. Hay, examined on the spot all the circumstances relating to the discovery and were convinced that the human remains were as old as the stratum in which they were embedded.[1] The human remains were entrusted to Dr Hrdlička, who found them to be

[1] Literature relating to the discoveries at Vero will be found in the *American Anthropologist,* 1917, vol. xix. p. 239 ; *ibid.,* 1918, vol. xx. p. 1. In the latter article Dr Oliver P. Hay of the Carnegie Institute gives a summary of various finds in North America where human remains and bones of Pleistocene mammals have occurred together in the same geological deposit.

identical in all their characters with the bones of American Indians.[1]

Further evidence in support of man's antiquity in North America is to be found as we journey northwards along the Mississippi, and reach those States which were covered by the ice-sheet at intervals of the Pleistocene period. For our present purpose it is more profitable to leave the Mississippi and follow its great tributary, the Missouri. At Kansas City we reach the " farthest south " of the ice-sheet. The loess deposits are everywhere abundant, forming high terraces or bluffs on either side of the Missouri. On the west bank of the river, some distance above Kansas City, near Lansing, is the farm of Mr M. Concannon. In 1902, Mr Concannon and his sons made a tunnel into the terrace of loess, on the side of the valley, to serve for the storage of apples and other farm produce. At a distance of 70 feet from the entrance of the tunnel, and at a depth of over 20 feet below the surface of the land, a human skeleton was found. Somewhat nearer to the entrance a child's jaw and an artificial chert chip were found.

There is no doubt as to the authenticity of the discovery at Lansing, nor is there any room for difference of opinion regarding the kind of man discovered. The skull is now in the National Museum, Washington. Both skull and skeleton have been examined and described by Dr Hrdlička. They are parts of a man of medium stature (about 1·65 m.), and about fifty-five years of age. " All the parts of the skeleton, and particularly the skull, approach closely in every character of importance the average skeleton of the present-day Indian of the Central States. . . . The forehead is somewhat low and sloping when compared with that of a well-developed skull of a white man, but appears normal in comparison with the forehead of undeformed skulls of Indians." The dimensions are such that the Lansing skull would fit exactly within the conventional frame used for modern

[1] Bureau of American Ethnology (Smithsonian Institution), *Bulletin* No. 66, 1918.

specimens of average size. The length is 189 mm.; the width, 139 mm.; the height of the vault above the ear-holes, about 122 mm.; the brain capacity a little over 1500 c.c.—in all respects a well-developed skull of the modern type. Clearly the men living in Kansas when the loess at Lansing was being deposited had all the physical characters of the American Indian.[1]

As regards the age of the Lansing terrace, in which these human remains were found, the late Dr G. Frederick Wright, who had given a lifetime to the study of glacial deposits, had no doubt. "A question has been raised," he wrote,[2] " as to whether the deposit of loess at Lansing was original or secondary. Professor T. C. Chamberlin maintained that the evidence was doubtful, and that it might be a secondary redeposition of the material, of great age indeed, but much younger than the main body of loess in the valley. Professor N. H. Winchell and Dr Warren Upham (both very high authorities upon such subjects), after repeated visits, adduce overwhelming evidence that the deposit is original, and that the skeleton was buried by the loess at the time of its deposition during the 'Iowan' stage of glacial recession." The " Iowan " interglacial period preceded the final or " Wisconsin" glacial phase, and followed the " Illinoisan" glacial phase.[3] The age attributed to the Lansing skeleton is thus older than that given for the Trenton fragments.

Another discovery of the remains of " loess men " was made some distance farther to the north. The city of Omaha is situated on the west bank of the Missouri, about 150 miles above Lansing. Some ten miles north of Omaha, the State of Nebraska, on the west side of the Missouri, " presents some rather bold elevations composed of accumulations of loess, modified in contour

[1] Many skulls and other remains, found deep in the loess, have been described by Dr C. W. M. Poynter, *American Anthropologist*, 1915, vol. xvii. p. 509.

[2] See reference on p. 460.

[3] The writer here follows Dr Wright's terminology.

by the action of wind and rain. The southern portion of one of the most prominent of these elevations, known as Long's Hill, consists of a ridge, about 600 yards long, running parallel with the Missouri. The ridge is covered with timber of recent growth." [1]

In 1906, Mr Robert F. Gilder, of the Omaha *World Herald*, commenced a series of excavations in a mound on Long's Hill. The mound had, at a previous date, been excavated by a party in search of the remains of the famous Indian chief, Black Hawk. Beneath the level of the mound, Mr Gilder's excavations revealed the remains of a number of human skeletons. With or near the bones several stone implements were found. Amongst these were two flint blades of the ordinary type. When a question subsequently arose as to the antiquity of these human remains, Professor E. H. Barbour, of the University of Nebraska, undertook the conduct of all further excavations. The result of his exploration was to show that fragments of the human skeleton were found at a depth of $11\frac{1}{2}$ feet in loess which had apparently never been disturbed since its deposition. Professor Barbour was convinced that the deeper human remains were as old as the deposit in which they were embedded. In his original excavation, Mr Gilder encountered, at a depth of 5 feet below the surface of the mound, a layer of clay, hardened by fire. Above this layer of baked clay were found remains of at least twelve individuals, representing men, women, and children. Beneath the baked clay stratum the remains of eight or nine bodies were unearthed, some of the fragments lying as much as $11\frac{1}{2}$ feet below the overlying surface of the land. Dr Hrdlička made a minute examination of these skeletal remains, and found that they possessed all the features which characterise the American Indian. The foreheads of some of the men's skulls were particularly low and receding, with strongly marked supra-orbital ridges—features which still occur in certain Indian tribes of the Central States.

I agree with Dr Hrdlička that at Long's Hill we have

[1] Quotation from Dr Hrdlička's description.

to deal with an ancient Indian cemetery. The question is : How ancient is that cemetery ? In Europe we find the custom of burial practised as early as mid-Pleistocene times. The evidence we have obtained at Trenton, at Natchez, and at Lansing justifies us in regarding North America as already inhabited by races of Indians during deposition of the loess. Is it not probable, then, that the earliest burials at Long's Hill date back to that interglacial phase which saw the deposition of the loess ?

It is clear from the researches published recently by the late Professor N. H. Winchell [1] that the Middle States of America were inhabited at an earlier date than is indicated by the discoveries just described. The loess men are supposed to belong to the last interglacial period —the milder interval between the last two phases of glaciation, the " Illinoisan " and " Wisconsin " phases. Beneath the deposits of the Kansan glaciation, which preceded the Illinoisan, Professor Winchell has found stone implements of a rude Palæolithic type, fashioned by the men who lived before the great Kansan glaciation. The remains of the men of that period have not yet been discovered.

From the Middle States we now pass westwards to the Pacific slopes in search of the ancient men of America. The story of the Calaveras skull, although grown stale from frequent repetition, cannot be passed over.[2] It is the " bogey " which haunts the student of early man— repelling some, fascinating others, and taxing the powers of belief of every expert almost to breaking-point. The skull itself—or what was found of it, for the greater part of the vault was missing—is now preserved in the Peabody Museum of Harvard University. It passed into the Peabody Museum in the following manner. Soon after its discovery in 1866, Professor J. D. Whitney, State Geologist of California, having verified its reputed

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[1] N. H. Winchell, " The Palæoliths of Kansas," *Minnesota Hist. Soc.*, 1913, vol. xvi. pt. i.

[2] For the literature referring to the history and nature of the Calaveras skull, see reference on p. 473.

history, brought the skull to Harvard University, and examined it in conjunction with Professor Jeffreys Wyman, one of the most skilled anatomists then living. The matrix of gravel which adhered to the skull was observed to be similar in character to that of the gold-bearing stratum in which the skull is said to have been found. In Professor Wyman's opinion, there were no signs of an inferior race in the characters of the skull. "It agreed," he wrote, "with other crania from California." A subsequent examination by Dr Hrdlička confirmed Professor Wyman's observations. On searching the great collection of human crania in the National Museum at Washington, Dr Hrdlička found two crania and some fragments of skulls from caves in Calaveras county, California, collected in 1857. One of these cave skulls is, in all essential features, closely related to the Calaveras specimen. The cave skulls show a greyish, calcareous, stalagmitic deposit, much like that which partially covers the Calaveras skull. In Dr Hrdlička's opinion, the infiltration and fossilisation of the Calaveras skull furnishes no test of its antiquity. The fact that the Calaveras skull is similar in form and in state of preservation to Indian skulls found in the Calaveras county must raise a suspicion as to the authenticity of the original specimen. It does not prove, however, that the original specimen is not really ancient. We have seen from the discoveries made in the loess deposits how persistent the American-Indian type may be.

If we regard the Calaveras skull as really a cave specimen, in spite of its history, there still remain other mysteries connected with the ancient bed of the Stanislaus even more difficult of solution. The skull was not the only evidence of man in the ancient gold-bearing river gravels in Calaveras county. These gravels lie buried under tides of lava which swept the western flanks of the Sierra Nevada in the Miocene and Pliocene periods. There are the most circumstantial accounts of the discovery, in the gravel beds of these ancient Pliocene streams, of stone mortars, stone pestles, hammer stones, spear-heads, etc., not only by miners, but by expert and

reliable geologists. Indeed, were such discoveries in accordance with our expectations, if they were in harmony with the theories we have formed regarding the date of man's evolution, no one would ever dream of doubting them, much less of rejecting them. The consequence of accepting the discoveries of Calaveras county as genuine have been well expressed by Professor W. H. Holmes, when he presented the results of his investigations to the Smithsonian Institution in 1899.[1] " To suppose that man could have remained unchanged physically, mentally, socially, industrially, and æsthetically for a million of years, roughly speaking (and all this is implied by the evidence furnished), seems in the present state of our knowledge hardly less than admitting a miracle." It is equally difficult to believe that so many men should have been mistaken as to what they saw and found. In the meantime, and until the matter of Pliocene man in California has been finally settled by a new and systematic exploration, we must be content to return the same verdict for Calaveras as for Castenedolo—the Scottish verdict of " not proven." [2]

The reader must not think, because our journey across the States along a tract of country which at one time lay buried beneath an extension of the Arctic ice-sheet has revealed no strange, primitive, or new type of human being, that it has been made in vain. On the contrary, we have received the most ample confirmation of the conclusions forced on us by the evidence in Europe, viz. that the antiquity of the modern type of man is much greater than is usually supposed.

In the opening paragraphs of this chapter I expressed the view generally accepted by anthropologists that

[1] " Review of the Evidence relating to Auriferous Gravel Man in California," *Smithsonian Reports*, 1899, pp. 419-472 (issued 1901).

[2] Of recent years many discoveries of fossil man have been reported from California. The evidence relating to these discoveries was summarised in *Science* (1924, vol. lx. p. 1) by Dr John C. Merriam of the University of California. He finds that none of the human remains could be assigned to a Pleistocene date with certainty.

man's origin in the Old World was a matter beyond question. Quite recently my friend, Dr Henry F. Osborn, has upset the complacency of Old World anthropologists by announcing the discovery in America of an extinct type, related both to ape and to man.[1] The site of this discovery lies in a quarry at Snake Creek in the western part of the State of Nebraska, some 350 miles from the loess bluffs at Omaha, where we have been examining
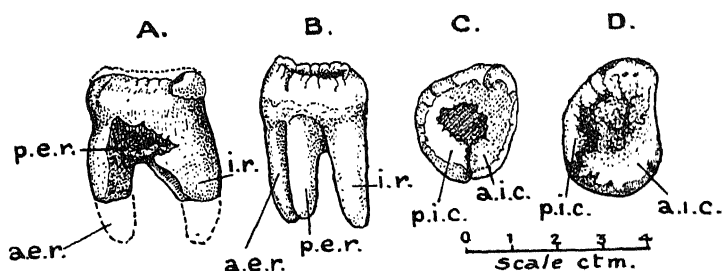
FIG. 164.—Comparison of the second molar of Hesperopithecus with the third upper right molar of an orang.

A. Posterior aspect of the fossil tooth of Hesperopithecus.
    a.e.r., anterior external root with missing part indicated.
    p.e.r., supposed attachment of posterior external root.
    i.r., internal root, completed by stippled outline.
    This drawing was made from a cast which Dr Henry F. Osborn presented to the Museum of the Royal College of Surgeons.
B. Corresponding view of the third upper molar of an orang.
C. The chewing surface of the fossil molar.
    a.i.c., anterior internal (lingual) cusp.
    p.i.c., posterior internal cusp.
D. Corresponding view of the third molar of an orang.

the remains of man. In Snake Creek quarries there are exposed certain beds, middle Pliocene in date, which contain fossil remains of a fauna so Asiatic in its characters that it is necessary to suppose that when these beds were laid down, or before they were deposited, America was united to Asia, thus making it possible for early precursors of man or ape to make their way from the Old World to

[1] Dr Henry F. Osborn, "Hesperopithecus, the First Anthropoid Primate found in America," *American Museum Novitates*, 1922, No. 37. See also *Nature*, 1922, vol. cx. p. 281 ; also "Further Notes on the Molars of Hesperopithecus," by Dr William K. Gregory and Mr Milo Hellman, *Bull. American Mus. of Nat. Hist.*, 1923, vol. xlviii. p. 509.

the New. Such a possibility had been foreseen. A Nebraskan geologist, Mr Harold J. Cook, kept his eye on these Pliocene beds of Snake Creek Quarry, and on 25th February 1922 he informed Dr Osborn: " I have had here, for some little time, a molar tooth from the upper or Hipparion beds, that very closely approaches the human type." On the day the tooth arrived at the American Museum of Natural History, New York, Dr Osborn wrote to Mr Cook: " The instant your package arrived, I sat down with the tooth, in my window, and I said to myself: It looks one hundred per cent. anthropoid. . . . We await, however, Dr Gregory's verdict tomorrow morning. . . . We may cool down to-morrow, but it looks to me as if the first anthropoid ape of America had been found by the one man entitled to find it— Harold J. Cook."

On the morrow there was no cooling down ; Dr W. K. Gregory, a leading authority on the shapes taken by the teeth of apes and men in past and in present times, took Dr Osborn's point of view ; both agreed it was an upper molar tooth of the right side. Dr Osborn at first regarded it as a third molar or wisdom tooth, but accepted Dr Gregory's opinion that it was the one in front, the second molar. It was discovered, also, that there was another molar of the same kind (a third upper molar) already in the Museum, found by Dr W. D. Matthew in 1908. The fossil molar sent by Mr Cook, that of an unknown or unidentified Pliocene animal, had features which were peculiar and puzzling. It had resemblances to the corresponding tooth of a chimpanzee ; it had features which were reminiscent of the molar of Pithecanthropus, and certain likenesses to the molars of modern man, and yet differed quite decidedly from all these. Dr Osborn therefore concluded that it must have belonged to " a new and independent type of primate " to which he gave the euphonius name, *Hesperopithecus*—the Western Ape. As to the exact position of Hesperopithecus in the family tree of man and ape, Dr Osborn was careful to say in his original description : "We

must seek more material before we can determine its relationships."

The identification of the kind of animal to which this famous fossil tooth originally belonged is difficult because of several circumstances. In the first place, its crown is worn by use, and worn in a way which I have never seen in a primate tooth. The dentine is exposed on its central area (fig. 164, C), while representatives of its cusps are left round the margin of the crown. We have thus only imperfect cusps to guide us and they have undergone certain retrogressive changes which are most frequently seen in third molar teeth, the least reliable of teeth when we come to estimate affinities. It will be noticed, too, that the anterior internal cusp (fig. 164, C) has undergone a greater reduction than the posterior internal cusp, a circumstance I have never observed in a primate molar tooth. The difficulties of identification are further increased by the fact that the tooth has fared badly after being detached from the jaws; it has been rolled and polished, it has become cracked and fissured; one root has been broken away altogether (fig. 164, A), while the two remaining roots have lost their tips. It is small wonder, then, with only the cast of such an imperfect specimen before them, very competent authorities have assigned the Snake Creek molar, not to a primate, but to an extinct bear[1] and to an extinct horse.[2] On the other hand, Professor G. Elliot Smith[3] gives Dr Osborn's identification his whole-hearted support. For my part, I am content to await the results of further discovery which is certain to be stimulated by Dr Osborn's expression of a definite opinion. His courage deserves to be vindicated, but on the evidence now available I do not think the primate nature of Hesperopithecus can be upheld.

[1] Sir A. Smith Woodward, *Nature*, 1922, vol. cix. p. 750.
[2] Professor Schlosser, in Zittel's *Grundzüge der Palaeontologie*, 1923.
[3] *Illustrated London News*, 24th June 1922.

CHAPTER XXV

AT the time Boucher de Perthes was striving to convince his contemporaries that man had existed in Europe with extinct forms of animals, a famous Danish traveller and naturalist, Dr Lund, was exploring caves in Brazil and coming to a similar conclusion as regards the antiquity of man. He left Europe in 1835 when the tide of curiosity in man's antiquity was rising. In 1844 he was able to report that he had examined eight hundred caves, in the limestone hills of Lagoa Santa, in the Brazilian province of Minas Geraes. Six of these caves yielded remains of man—some so abundantly that they must have served as ancient sepulchres, as was the case in early Europe. Up to 1844, Dr Lund remained unconvinced that these early Brazilians, whose bones he found in the caves, had been contemporaries of the extinct animals represented so plentifully in cave deposits. At last he found embedded in the floor of a cave the bones of man and of extinct animals, mingled together, and in a like condition of fossilisation. If the bones had been of any animal other than man, their antiquity would never have been questioned, but being human all sorts of doubts were raised as to how and when they became mixed with remains of extinct animals.

The final result of his investigations Dr Lund gave as follows : [1]—

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[1] See Dr Hrdlička's excellent, if somewhat critical, account of Lund's discoveries : " Early Man in South America," *Bulletin No. 52, Bureau of American Ethnology*, 1912, p. 159.

"In view of the facts to which I have here referred, there can then remain no doubt as to the existence of man on this continent in an epoch anterior to that in which the last races of the gigantic animals whose remains abound in the caves of this country became extinct, or, in other terms, as to his existence here anterior to the historic period.

"As to the ethnographic peculiarities of the skulls from this deposit, I had occasion to confirm my former conclusions, namely, that they offer all the characteristic features of the American race; and I have firmly convinced myself that the extraordinary depression of the forehead which is observed in some of the individuals is not artificial."

It must be kept in mind that Dr Lund's investigations were carried out long before methods of precision and of dating had been applied to cave exploration in Europe. As our knowledge of the early cultures of South America increases, the objects of human workmanship which were collected by Dr Lund during his investigations of the deeper strata of the caves may give a clue to the antiquity of the human remains. We do not know when the strange animals, which apparently lived at the same time as the Brazilian cave-men, became extinct, but if we apply to South America the rules which guide the palæontologist elsewhere, we must regard them as being at least as old as the latter part of the Pleistocene period.[1]

As to the kind of man discovered by Dr Lund in the Lagoa Santa caves, there is no difference of opinion. Those who have examined his collections in the University Museum, Copenhagen, and in the Natural History Museum, South Kensington, London, agree that, in racial features, those ancient Brazilians do not differ from tribes still living in South America. The skulls

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[1] I doubt if this inference is valid. There is, in 1924, a growing belief that the extinction of wild species took place at a much later date in America, both north and south, than in Europe. It is probable that man is responsible for the extinction of the larger Pleistocene mammals.

are not unlike those of the low-browed " Nebraska loess men." We have in Dr Lund's discoveries further evidence of the persistency of the American-Indian type.

Dr Lund's discoveries gradually passed out of notice, and South America, as a possible home of ancient man, ceased to attract attention until the commencement of the present century, when there was a sudden revival of interest. That revival was entirely due to Dr
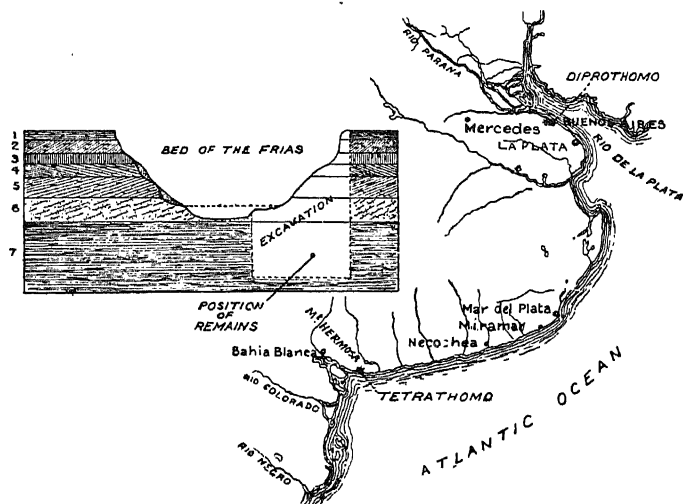
FIG. 165.—Sketch map of the sites of Ameghino's chief discoveries of ancient man. Inset is his section across the Frias, showing the strata and the position of the exploratory trench.

Florentino Ameghino. He became interested in pre-historic research at an early age.[1] In 1873, being then in his nineteenth year, he made his first discovery of ancient man. At that time he was living in the town of Mercedes, some distance to the west of Buenos Aires (see fig. 165), on a flat sweep of the pampas across which there meandered a stream named the Frias. On one side

[1] For an account of Ameghino's anthropological discoveries, see Robert Lehmann-Nitsche's " Nouvelles Recherches sur la Formation Pampéenne," *Rivista del Museo de la Plata*, 1907, vol. xiv. pp. 143–488. Also Dr Aleš Hrdlička's work referred to on p. 286. Dr Florentino Ameghino died in 1911.

of the stream, the banks of which rose over 6 feet above the level of the water, young Ameghino began to disinter the partially exposed carapace of an extinct Edentate near to a spot at which he had previously found a human skull. In the soil round and under the carapace he was surprised to note traces of charred wood. He then sank a trench on the side of the stream, in order that he might examine, in a systematic manner, those strata containing traces of man (fig. 165).

He carried the trench down to a depth of about 5 feet below the bed of the stream, and about 10 or 11 feet below the surface of the bank. Altogether seven strata were exposed (see fig. 165); in the deepest layer, below the level of the bed of the stream, he found human remains. In the same stratum as the human bones he found parts of extinct animals, living animals, worked flints, fragments of charred bone, bones which were broken, perforated, and incised, baked earth, and a great abundance of charcoal. He believed he had discovered " the fossil man of Argentina." In 1875 the Argentine Scientific Society awarded him a diploma on account of his investigations, but in 1878, when he wished the Society to publish an account of his discovery, it refused to help him. Thereupon he carried his results to Europe, and obtained the sympathetic attention of the leading anthropologist in France —Paul Broca.

Certain defects which mar all of Ameghino's scientific papers are apparent in his very first effort—a lack of precision and of detail, and particularly a decided tendency to overestimate the antiquity of all the geological strata of the Argentine Republic. The stratum on the Frias (fig. 165) which contained the human remains he regarded as of Pliocene date, and supposed the bones had become naturally entombed, not deliberately buried. He was misled by thinking that a stratum which contained the remains of extinct animals must necessarily be old. The accepted opinion regarding these Pampean formations is that they are alluvial deposits belonging to the Pleistocene period—formations

not unlike the loess of the Mississippi valley in manner and date of formation.[1] There can be no doubt that the bones were buried by human agency. The greater part of a skeleton of an old woman of short stature (1·500 m.) and fragments of another individual were represented in his first discovery. There is no question, then, that Dr Ameghino's first discovery represented a burial. It is clearly not a burial made from the present land surface, but when and how it was made are problems which cannot now be solved definitely. The human remains are clearly of some degree of antiquity.

In 1902, at the age of forty-eight, and after an uphill life-struggle, Ameghino found himself Director of the National Museum of Buenos Aires. With a series of discoveries, following each other in rapid succession, he really startled the anthropologists of Europe. He claimed to have discovered fossil forms which demonstrated the evolution of modern man—or of a form of man of the modern type—in the southern regions of South America. The oldest and most primitive human ancestor he named Tetraprothomo, and regarded the only remains which were found of this ancient, human type—an atlas and a thigh bone—as of Miocene age. The remains of Tetraprothomo were discovered at Monte Hermosa, on the east coast of Argentina, some distance north of the mouth of the Rio Colorado (see fig. 165).

The second and later stage in man's evolution—Diprothomo—was based on the fragment of a skull, obtained from a formation which he regarded as of early Pliocene date. The third link in Ameghino's human, ancestral chain was *Homo pampæus*, also a Pliocene form. The fourth and final stage, *Homo sapiens*, appeared in the Pleistocene deposits of the pampas.[2]

It will be sufficient to give a brief account of the discovery of Ameghino's early Pliocene forerunner of man—Diprothomo. In 1896 an English firm of contractors

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[1] See Dr E. Boman's " Encore l'Homme tertiaire dans l'Amérique du Sud," *Journ. de la Soc. des Americanists de Paris*, 1919, vol. xi. p. 657.

[2] For full account, see references on p. 479.

had almost finished the construction of a dry dock on the south bank of the La Plata, at Buenos Aires. The concrete floor of the dock had been sunk to a depth of 12·36 m. (40·7 feet) below the level of the water at low tide. Subsequently, an additional hollow, 20 inches deep, had to be sunk through the floor of the dry dock, reaching a total depth of about 42 feet below the level of low tide. In sinking the additional pit, the fragment of a human skull was found by a workman. The fragment was given to Mr Junor, who was in charge of the works, and by him it was presented to the National Museum, Buenos Aires. Thirteen years later, Dr Ameghino published an account of this fragment. The deep stratum of the Pampean formation from which it was extracted he regarded as early Pliocene in date of formation, and the fragment he conceived to be part of a small and peculiar skull of an ancient and extinct genus of humanity, which he named Diprothomo.

There is no reason why the specimen should be rejected as worthless because of its defective history. On the other hand, there are the very soundest grounds for rejecting Ameghino's conclusions as regards the age of the stratum and the nature of the cranial fragment. Geologists refuse to regard the stratum in which the fragment was found as older than Pleistocene, and anatomists are unanimous in regarding the cranial fragment as representing the frontal bone and part of the parietals of a human skull which in size and shape must have been very similar to skulls of American Indians.[1] From what has been shown in this and in the previous chapter, there is no reason for being surprised at the discovery of a fossil skull, showing American-Indian features, in a deposit of Pleistocene age. Ameghino's Diprothomo thus represents a man of the American-Indian type living in the Argentine during Pleistocene times.

[1] See Professor Schwalbe's " Studien zur Morphologie der südamerikanischen Primatenformen," *Zeitsch. für Morph. und Anthrop.*, 1910, vol. xiii. pp. 209–258.

Ameghino's Miocene form of man—Tetraprothomo—had also to go by the board. Only the atlas and the thigh bone of this strange evolutionary form were discovered. The thigh bone proved to be that of an extinct carnivorous animal of the cat genus, and as large as a puma ; but the atlas was human. Unfortunately, the antiquity of the atlas may very well be called in question. The exact stratum from which it was obtained is unknown.

There is no need to recount the remaining discoveries which have been made in the Argentine Republic. They are fully described by Dr Lehmann-Nitsche and by Dr Hrdlička.[1] The result of a survey of the discoveries of ancient man made in South and North America leads to the same conclusion, that we cannot trace man beyond a point in the Pleistocene period, and that the oldest human remains so far discovered, both of the northern and southern parts of the western hemisphere, are of the same American-Indian type. Indeed, the resemblance between the skulls recovered from deposits of a Pleistocene age in the United States and those found in the Pampean deposits of the Argentine Republic is very striking. They are not only of the same race ; they might belong almost to members of the same tribe. We have seen no evidence to lead us to suppose that any race preceded the American Indian in the new world.

Yet, one cannot conclude such a survey as this with any feeling of satisfaction or of certainty. We seem to leave so much unexplained. Those who have studied the ancient civilisations of America and the multitude of Indian languages, are of opinion that although they have been modified by influences which have reached them from time to time across the Pacific, yet they have undergone their own independent courses of evolution, and that to account for the great diversity of speech and of manner of living we must suppose that man's arrival in America is of ancient date. The animals which had been domesticated, and the numerous native plants which had been

[1] See references, p. 479.

brought under cultivation by indigenous races in pre-Columbian times, seem to point to an antiquity beyond that revealed by the discoveries of the geologist or of the anatomist.[1] The writer feels certain that human secrets still lie hidden in America. The discovery of implements of a Palæolithic type in the State of Kansas under deposits of the phase of maximum glaciation suggests an earlier history for man in America.[2] Dr Uhle has found in Pleistocene beds of Chili stone implements of the Amygdaloid or Acheulean type.[3]

With this chapter comes to an end our tour round the world in search of man's most ancient traces and forms. We have, in the next chapter, to return to England and note the most critical and important of all the discoveries of ancient man which has been made within her borders —that of Piltdown man. But I cannot leave the neighbourhood of Patagonia without mentioning a type of man found in this region of South America.[4] When in the island of Jersey in 1912, studying in the Museum in St Helier a collection of crania, a skull-cap was shown me with no exact history, but it was said to have come from South America, which I have since learned was indeed true—from Chili. It was in a semi-fossilised state, and my attention was particularly drawn to this specimen because it was an exact replica, in dimensions and in structural characters, to the famous Brünn skull-cap, described on p. 104 of this book. Since then I have had many opportunities of verifying the fact that this form of skull-cap is characteristic of the strong, tall natives of Patagonia. We have in truth, in these Patagonians, the survival of a Palæolithic race. Unfortunately we do not

[1] See *South American Archæology*, by T. A. Joyce, London, 1913, p. 189. Also *Anthropology*, by Professor A. L. Kroeber, 1924.

[2] See "A Consideration of the Palæoliths of Kansas," by N. H. Winchell, *Minnesota Hist. Soc.*, 1913, vol. xvi. pt. I.

[3] See *Revista de la Universidad de Cordoba*, 1923, vol. x. p. 110, an article by Dr Alfredo Castellanos on "La Limite Plio-pléistocène et le Problème de l'Homme tertiaires dans la Republique Argentine."

[4] See also note on p. 104.

know the facial features of the Brünn man nor the size or shape of his body, and therefore cannot say if he and the Patagonians are of the same breed; but of living human types this distant people seem to be the best representatives of the pioneers who made their way into America from Mongolia in Palæolithic times. They answer better to what one conceives to have been the proto-Mongolian type, than any of the other varieties of man now living in America.

CHAPTER XXVI

THE DISCOVERY OF THE PILTDOWN SKULL

ENGLAND owes much to the disciples of Gilbert White. Everywhere, especially within her southern parts, you will find them observing and recording those strange facts which, when rightly understood, will carry our island story leagues beyond the dawn of written history. The little jealousies and disputes which occasionally ruffle the serenity of their lives leave untouched the splendid freemasonry which binds them together, and which knows no distinction of class. The lord of the manor and the village shoemaker meet at this point on equal terms. These local historians are drawn from all classes ; the squire, the vicar, the lawyer, the doctor, the bank clerk, the watchmaker, the grocer, the baker, and the village labourer all enrol themselves amongst the followers of the immortal Gilbert.

It is to one of these men we owe the finding of the Piltdown skull, which, from an historical point of view, is the most important and instructive of all ancient human documents yet discovered in Europe. Mr Charles Dawson,[1] its discoverer, a lawyer by profession, lived in the historic town of Lewes, situated picturesquely in a gap of the South Downs where the Sussex Ouse breaks through from the Weald and empties its silent waters in the English Channel at Newhaven (fig. 166). It is just in such a quiet town as Lewes that we expect followers

[1] Mr Dawson died on 10th August 1916, aged fifty-two, deeply regretted by all who knew him, not only on account of his great discoveries but also because of his sterling ability and unselfish personality.

of Gilbert White to appear. It was in Lewes that Dr Gideon Mantell practised as a physician in the earlier part of last century, and spent his leisure time in making known to all the world the remarkable reptiles which abound in the old-world strata now exposed in the cup or hollow of the Weald. Mr Charles Dawson followed in his footsteps; for twenty years and more he spent his leisure hours in searching the strata of the Weald, and brought to light many things novel to science.
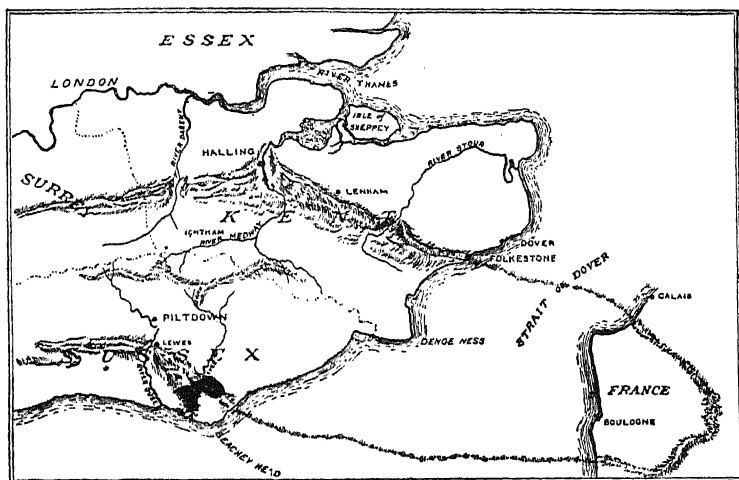
FIG. 166.—Sketch of the south-east corner of England, to show the Weald, the position of Piltdown, and the course of the Sussex Ouse. The former extension of the boundaries of the Weald to France is indicated.

About the time he began to search the Weald a new influence was at work among the naturalists in the south-east corner of England. Lewes is situated on the south side of the green cup of the Weald; on the other side of the cup, thirty miles north of Lewes, lies the Kentish village of Ightham, and it was here, in a grocer's shop, that the new influence had its mainspring—Mr Benjamin Harrison. He was a young man in 1859 when M. Boucher de Perthes was compelling his reluctant contemporaries to acknowledge that the elaborately worked flints he had recovered from the ancient gravel terraces

of the Somme, in the north-west of France, were the handiwork of long extinct races of man. Mr Harrison [1] searched the gravels of his own locality, and soon discovered implements of the same types as M. Boucher de Perthes had found in the deposits laid down in former times by the Somme. Mr Harrison, however, carried the history of flints a great stride further back. Little more than a mile north of Ightham rises up the chalky bank of the North Downs which forms the northern lip of the Wealden cup. Crossing the Pilgrims' Way, which winds along the foot of the bank or escarpment, Mr Harrison had, in his almost daily excursions, a stiff upward climb of some 500 feet to reach the plateau of the North Downs, stretching away northwards into the valley of the Thames. Here, in the gravel deposits of the plateau, immensely older than the terrace gravels of the valleys, Mr Harrison found rudely shaped flints, which he recognised as being of human workmanship. They were primitive in form when compared with the palæoliths from the valley gravels, and he distinguished them as "eoliths." Although he recognised them first in 1865 —fifty-nine years ago—eoliths were not accepted as genuine products of man's hand until 1888, when the late Sir Joseph Prestwich—a geologist noted for his sound judgment—brought them before the scientific world.

Even when Mr Dawson began his researches in the Weald thirty years ago, eoliths, although gradually gaining adherents, were still the subject of hot contention. It was about this period, too—the end of last century— that a great truth, the inception of which we owe to our colleagues of France, began to leaven the researches of the Wealden workers. This truth is simply the recognition that the law of change or progress, which influences all the worldly affairs of men, holds true not only of present but also of past generations of mankind. Every

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[1] For further details of Mr Harrison's busy life, see *Ightham : the Story of a Kentish Village*, edited by F. G. Bennett, F.G.S., The Homeland Association, Ltd., London. Also *Brit. Med. Journ.*, 1912, ii. p. 805. As already mentioned on p. 1, Mr Harrison died in 1921, aged eighty-three.

generation has its own distinctive fashions and ideas; it builds its houses, it tills its fields, it makes its implements, it writes its books, it wears its clothes and paints its pictures in a manner slightly different from the generation which went before it. It is not difficult to distinguish a house built in the time of Queen Elizabeth from one built in the time of her great successor—Queen Victoria. The law of evolution and of change has always held true. The French archæologists recognised that this law is valid for the men who shaped the implements found in caves and valley gravels.

When the stages in the evolution of these implements have been distinguished, we are provided with a scale of sequence of time to guide us safely and surely towards the very beginnings of humanity in the far past. Each generation of Palæolithic men we now know copied and modified the flint tools of an older generation. One has only to survey the researches which Mr Lewis Abbott has made in the deposits and strata of the Weald to see how fruitful the acceptation of this conception has proved to the Sussex naturalists.

From this cursory introduction the reader will perceive that Mr Dawson's discovery of fossil remains of man in the Weald of Sussex was not altogether a matter of chance. Business had taken him into the Weald. His way lay along quiet, sheltered country roads, following upwards the sluggish waters of the Ouse, until he reached that upland, open, and bracing country some eight miles to the north of Lewes. Here Piltdown Common is situated, a moorland tract, on which golfers may enjoy the " ancient " game under ideal conditions. The common is part of a wide sweep of fertile, well-wooded land, with old-world farm-houses, comfortable and sheltered, spread across it. Sussex churches, Sussex villages, and Sussex gardens make it a country worth seeing even by those who are not in pursuit of fossil man and his works. The land at Piltdown lies 120 feet above the sea; but when we look southwards to catch a glimpse of the English Channel, the green South Downs rise up, with Lewes at their foot,

and cut off the view. Westwards, the South Downs
continue their course along the seaboard, sheltering
Brighton from the north. In the wooded and undulating
country to the north-west lies the source of the Ouse,
some twelve miles distant. Standing on the common,
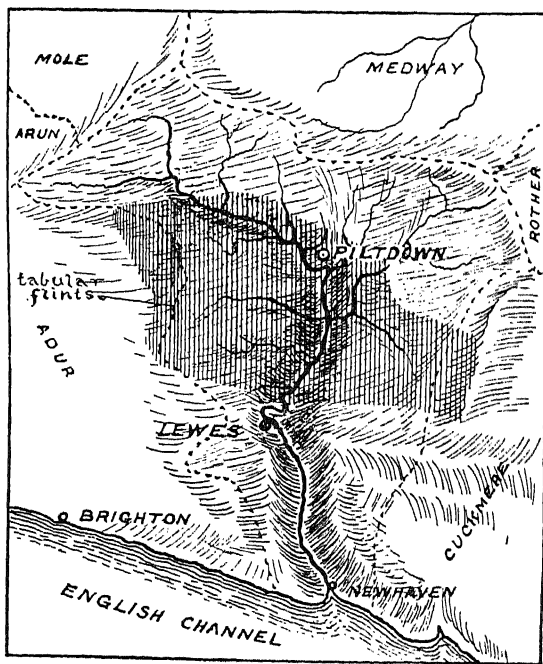
FIG. 167.—Sketch of the district drained by the Sussex Ouse, showing the
area over which Mr Dawson found peculiar tabular flints and traces
of ancient gravel deposits. (After Mr Dawson's illustration.)

we see that the Ouse is about a mile distant to the
west. In the course of time it has cut a valley through
the Piltdown plateau, until now its bed lies 80 feet below
the level of the common. It has a journey of fifteen
miles to make before it reaches the sea at Newhaven.

In the middle of the Weald, to the north, the land rises
to form a wooded ridge—the " forest " ridge—forming
the watershed between the Ouse and the Medway, a
tributary of the Thames. The " forest " ridge hides

from view the North Downs, which rise sharply up and separate the Weald from the Thames valley.

Having thus accompanied Mr Dawson into the Weald, he himself will take up the narrative, as told in a communication to the Geological Society of London.[1]

" Several years ago (1908) I was walking along a farm-road close to Piltdown Common, Fletching (Sussex), when I noticed that the road had been mended with some peculiar brown flints, not usual in the district. On inquiry, I was astonished to learn that they were dug from a gravel bed on the farm, and shortly afterwards I visited the place, where two labourers were at work digging the gravel for small repairs to the roads. As this excavation was situated four miles north of the limit where the occurrence of flints overlying the Wealden strata is recorded, I was much interested and made a close examination of the bed. I asked the workmen if they had found bones or other fossils there. As they did not appear to have noticed anything of the sort, I urged them to preserve anything that they might find. Upon one of my subsequent visits to the pit, one of the men handed to me a small portion of an unusually thick human parietal [2] bone. I immediately made a search, but could find nothing more ; nor had the men noticed anything else. The bed is full of tabular pieces of iron-stone closely resembling this piece of skull in colour and thickness ; and although I made many subsequent searches, I could not hear of any further find nor discover anything—in fact, the bed seemed to be quite unfossiliferous.

" It was not until some years later, in the autumn of 1911, on a visit to the spot, that I picked up, among the rain-washed spoil-heaps of the gravel pit, another and larger piece belonging to the frontal region of the same skull, including a portion of the left supraciliary ridge. As I had examined a cast of the Heidelberg jaw, it

[1] From the *Quarterly Journal of the Geological Society*, March 1913, vol. lxix. p. 117.
[2] The right and left " parietal " bones form the greater part of the roof and sides of the brain cavity of the skull.

occurred to me that the proportions of this skull were similar to those of that specimen. I accordingly took it to Dr A. Smith Woodward at the British Museum (Natural History) for comparison and determination. He was immediately impressed with the importance of the discovery, and we decided to employ labour and to make a systematic search among the spoil-heaps and gravel, as soon as the floods had abated. . . ." Their labours were rewarded in the spring of 1912 by the discovery of the greater part of a fossil human skull.

We propose to follow Mr Dawson to the site of the gravel pit. Leaving Piltdown Common, we throw open the white gate which guards the private approach to Barkham Manor—an English farm-house rendered homely and picturesque by the passage of centuries. The avenue leads us straight to the farm-house; the approach is flanked on either hand by a line of trees, which spring at regular distances from wide green margins, carpeted by Sussex turf. Here the farm carts come and go. Just before the house is reached the avenue of trees ends; the road is then bounded by a hedge on the right and an open meadow on the left, which sweeps up to the hospitable doorway. If the visitor is not sharp-eyed he will miss the pit. It lies on the right hand between the roadway and the hedge—merely a narrow trench some 4 feet deep. Even to the professional eye it is a most unlikely spot to yield the remains of fossil man, and the bones of the animals which flourished in his time.

The stratum of gravel is seen to be surprisingly shallow —rather less than 4 feet at this particular point. As the section of the side of the trench shows (fig. 168), the gravel rests on a bed-rock formed by one of the ancient Wealden rocks—the Hastings beds. The gravel is stratified—laid down by running water. The lower or " dark " layer is the most important. Although scarcely 6 inches in thickness here, it increases in other places to 1½ feet. The sand and gravel of this layer is cemented together by iron oxide; everything embedded in it is stained a deep brown from iron impregnation, washed out from ancient

Wealden deposits. Then under the dark or fossil-bearing stratum comes a thin basal layer of yellow clay, which became important as digging went on. This basal layer, which was first mentioned by Mr Dawson in 1914,[1] is shown in fig. 169A. It is interposed between the fossil-bearing stratum above and the Hastings beds below, and is about 8 inches thick.

6^{in}

3½f^{t}

6^{in} {EOANTHROPUS REMAINS

HASTINGS BEDS
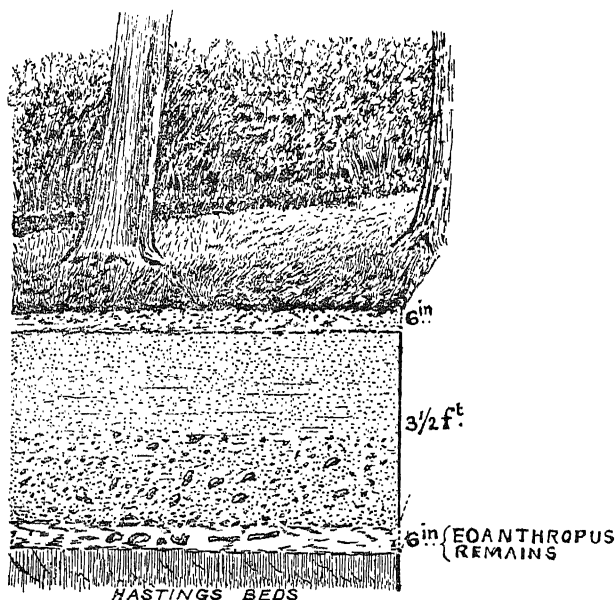
FIG. 168.—Diagrammatic sketch of the gravel deposit in which the Piltdown skull was found. The section represents the face of the pit, with the hedge and trees beyond.

It was from the deeper or "dark" layer that Mr Dawson removed the right half of a peculiar human lower jaw. In the same stratum Sir A. Smith Woodward found a small but very important part of the skull— the part which gives us a reliable index to the width and form of the posterior or occipital part of the head. There can be no doubt that it was from this dark layer that the piece of skull handed to Mr Dawson

[1] *Quart. Journ. Geol. Soc.*, 1914, vol. lxx. p. 82.

by the workmen came and the other fragments recovered from the spoil-heaps. In the dark layer eoliths were also found—the rudely worked implements which Mr Benjamin Harrison had discovered on the Kentish plateau in 1865. In some of these the edges were sharp, showing that they had come to rest soon after being washed into the bed of the ancient Ouse ; others were blunted and abraded, showing that they had been rolled for a long distance before coming finally to rest in the bottom bed at Piltdown. In this same bed was found the much-rolled cusp of the tooth of a Mastodon —a primitive genus of elephant which was in existence before even the Miocene period began ; it is supposed to have been dislodged from some ancient stratum and redeposited here during the denudation of the Weald. More remarkable still, Sir A. Smith Woodward was able to identify two unrolled fragments of a molar tooth belonging to Stegodon—a form of elephant whose remains are known to occur in Indian deposits of the Pliocene period, but never before found in Western Europe. The shallow pocket of gravel at Piltdown, Sussex, yielded not only a new form of man, but an elephant which was new to the fauna of ancient England. The same stratum also yielded portions of two teeth of a hippopotamus, and two molar teeth of a beaver which has not yet been found in deposits older than the Pleistocene. The beaver may have been in existence during the Pliocene period, but we have no evidence of this. The contents of the pocket of gravel at Piltdown were a surprise to geologists. The animal remains indicate that the deeper layer of gravel was laid down in the Pliocene period—a very remote age if we try to count by years.

In the gravel, just above the deeper or dark layer, were found worked flints of a more highly evolved type than eoliths. They are not stained brown as are the eoliths, but are of a " brilliantly coloured iron-red." Mr Dawson regards them as belonging to that stage of Palæolithic culture known as the " Chellean," or to an

indefinite and older period, which saw the early evolution of the Chellean culture—the "pre-Chellean." In a field which adjoins the Piltdown pit, just beyond the hedge, Sir E. Ray Lankester picked up, in 1913, a flint implement, brilliantly red in colouring, which was not of the Chellean type, but had resemblances to the "rostro-carinates" of the Red Crag deposits and also to early Mousterian implements.[1] It has to be noted, however, that pre-Chellean or early Chellean flints did not occur in the deeper layer in which the human and animal remains were found ; they are not stained dark brown as are the eoliths and bones. Mr Lewis Abbott, whose opinion in all that pertains to the geology of the Weald deserves serious consideration, has no hesitation in regarding the deeper stratum as Pliocene in the date of its formation, while the upper and looser strata he regards as having been disturbed and redeposited at a later date.

As regards these more highly worked implements from the Piltdown gravel, there is room for a difference of opinion. No one has a better right to give an expert judgment on such implements than Mr J. Reid Moir. The result of a minute examination of the better worked flints from Piltdown led him to the following conclusions :—

"These later and more Palæolithic-looking specimens do not, however, appear to me to be of such definite forms as to be classifiable. They most certainly do not agree with the usual definition of a *Chelles* implement ; and by the large surface of fracture and irregularity of the secondary flaking I would place them in a period preceding the *Chelles* phase. In fact, I have myself found implements very similar to these in deposits which, without doubt, considerably predate those containing the *Chelles* type. I therefore consider that, as these pre-Chellean implements are the latest constituents contained in the Piltdown gravel, the deposit must be very ancient. There is also no doubt that a very long period intervened between the time when

[1] *Man*, 1921, vol. xxi. p. 59.

the Eolithic implements and the later or pre-Chellean type were made. This intermediate period is apparently not represented by implements of the Piltdown gravel."

We have thus evidence from two independent sources that the Piltdown gravel pockets contain animal remains and human artifacts of two different ages. The bottom layer, with its animal remains and eoliths, is apparently of Pliocene date; the overlying beds belong to about the commencement of the middle third of the succeeding period—the Pleistocene.

These surprising discoveries in the gravel pit at Piltdown were made in rapid sequence before the end of 1913. Others of an even more astonishing nature were to follow. Mr Dawson, Dr Smith Woodward, as he then was, and their helpers, with pick, spade, and sieve, continued to explore the neighbourhood of the pit with enthusiasm as well as discrimination. In 1915 came the most amazing of all the Piltdown revelations.[1] In the black soil under the hedge, a few feet from the refuse heap which yielded the first fragment of the Piltdown skull, Mr Dawson exposed a great fossil slab of bone, cut from the femur of an elephant and which had been worked, while it was still fresh, into an implement somewhat resembling a cricket-bat in size, but scarcely so in shape (fig. 169). The cuts, made by a sharp implement, were clearly visible at the pointed end. Through it a hole had been bored near one side, but the original margin having broken away, the hole appeared as a grooved notch on the side. That it had been thrown aside by labourers when digging the pit, there was no doubt, for it had been broken by a blow from a pick. Further, it was still encrusted with the characteristic yellow clay of the deepest bed, the thin stratum which lies under the dark fossil-bearing layer, which contained the remains of Eoanthropus (fig. 169A). Sir A. Smith Woodward has no hesitation in assigning this implement to the deepest bed, so we accept it as certain that it was

[1] "On a Bone Implement from Piltdown, Sussex," by Charles Dawson and A. Smith Woodward, *Quart. Journ. Geol. Soc.*, 1915, vol. lxxi. p. 144.

fashioned by the predecessors or contemporaries of Piltdown man. Further, this distinguished geologist has never agreed with those who regard the Piltdown gravels as having been deposited at two different dates; all along he has maintained that the three strata, namely, the bottom layer of clay, the dark fossiliferous bed and the upper gravel, are deposits of the same age, all of them having been laid down at the beginning of the Pleistocene period.

Our visits to the fossil-laden caves of Malta and of Rhodesia have prepared us to recognise the prowess of ancient man as a hunter, but we scarcely expected to find that there were men in England, at the very beginning of the Pleistocene period, when the forest beds were forming at Cromer, who had capacity, dexterity, and resource to fashion such a bone implement as that found at Piltdown by Mr Dawson.

The sketch given in fig. 169 will help the reader to appreciate the difficulties involved in fashioning such a weapon from the unwieldy femur of an elephant. The only kind of femur in the

FIG. 169.—The Piltdown bone implement applied to the hinder and upper part of the femur of an extinct species of elephant —*Elephas meridionalis*. The ancient hunters apparently worked the implement from the area which it has been made to cover. (Sketched from the illustration prepared by Sir A. Smith Woodward and published by him in the *Quarterly Journal of the Geological Society*, April 1914.)

British Museum which was big enough to yield an implement with the contour and dimensions of the

one found by Mr Dawson, was *Elephas meridionalis*, a species which became extinct in England about the time the deposition of the Cromer forest beds was completed.   The dense material which makes up the massive thigh bone of an elephant is not an easy medium in which to work even when the bone is fresh. It is still more difficult to deal with when it becomes dry, hard, and brittle.   The clean cuts on its pointed end show that the implement was wrought soon after the elephant's death, which we may infer took place at the hands of the Piltdown hunters.   Somehow a large slab of bone was removed from the hinder and upper side of the shaft, and out of this slab was fashioned an implement 16½ inches long (41 cm.), 3½ to 4 inches wide (9–10 cm.) ; at its pointed end it has a thickness of 2 inches, while towards its wide, rounded, scoop-shaped end it measures only a little over an inch in thickness.   Even if provided with steel chisels, saw, and hammer, we moderns should find such an undertaking beset with difficulties, all of which were overcome by Piltdown man with his rude tools of flint.   To what use the implement was put we cannot tell, for a weapon of the kind has never been met with in any part of the world, nor amongst any race of men.   Until this discovery, we were under the belief that bone was first worked into tools in late Mousterian times, but now we know that in England, long before the first Pleistocene glaciation had covered her eastern lands with a thick blanket of chalky boulder clay, this art had been discovered and applied in a manner which bespeaks a thinking brain and a skilful hand.

Meantime, however, we are supposed to be standing by the pit, almost at the front door of a picturesque farm-house in Sussex.   The present stream of the district—the Ouse—is nearly a mile distant, and 80 feet below the plateau on which the farm-house is placed. When the gravel of the pit was deposited, however, the Ouse flowed over the ground on which we stand— shifting its bed from time to time, now laying down a new stratum of gravel, and many a year later coming

back to plough it up again and mix deposits together of very different ages. It is clear that the face of the country must have greatly changed since the Piltdown gravels were laid down. The level of the land has risen and fallen several times. When the Piltdown gravels were laid down the level was 100 feet lower than it now is.
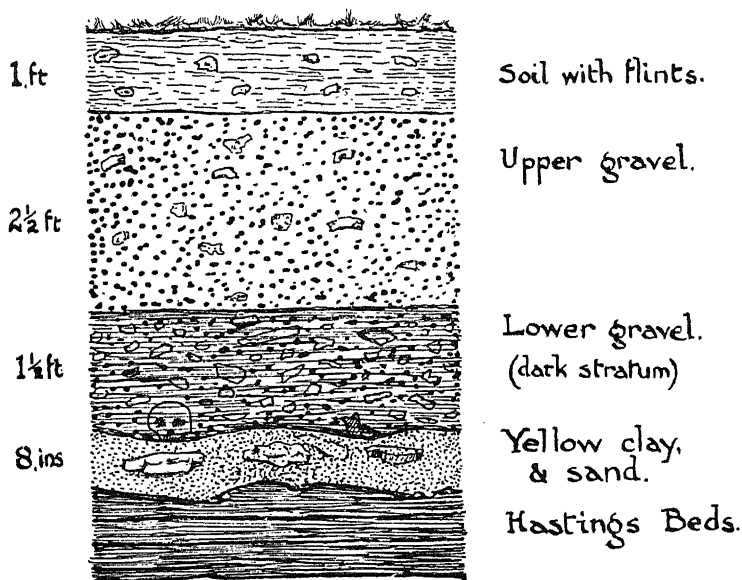
FIG. 169A.—Section of the strata which lie over the Hastings beds at Piltdown. (After Dawson and Smith Woodward, 1914.) The bone implement is believed to have come from the deepest stratum above the Hastings beds.

As we leave the pit there are several thoughts which must occur to everyone. How many of those ancient ancestors of ours have already been dug up and used as metal to mend our roads? Had it not been for Mr Dawson, Piltdown man, his flints, and the remains of ancient elephants, hippopotamus, and beaver would have long ere now been ground to dust under the wheels of lumbering farm wagons. Another surprise is that so shallow a deposit, lying almost on the surface of the open land, can yield evidence of so ancient

a phase of the earth's history and of the men of England. Had it chanced, however, that the human remains thus recovered had been of a type similar to the men still living in the world, what would have been the result ? Judging from what has happened in other cases, the universal verdict would have been that some mistake had been made, so strong is the belief that modern man is of modern origin. The condition of fossilisation of the human bones would then have had little influence on the verdict, for the rate at which bones become fossilised, when they become impregnated with iron, is extremely rapid. By good fortune, the human remains, as we shall see later, carry most certain indications of great antiquity in their peculiar features.

The ancient human remains at Galley Hill, at Ipswich, at Castenedolo, and probably also at Olmo, were apparently interred in the places where they were found. At Piltdown we are concerned, as at Heidelberg and at Trinil, with fragmentary remains which had been naturally entombed in the bed of an ancient stream. Only parts of the skull were found at Piltdown, and, as at Trinil in Java, the fragments were scattered some yards apart. The individual may have been drowned and dismembered in the stream, or the skull may have been exposed on dry ground and subsequently swept, with other animal remains, into the stream in a time of flood.

A reference to fig. 170 will show how much of the human skull was recovered. The greater part of the left half of the brain case was found—only the middle part of the forehead and a part of the posterior or occipital bone were missing. The part of the occipital bone which was missing on the left side is present on the right, and it is thus possible, for the right and left sides of the skull are approximately symmetrical, to reconstruct the width and form of the hinder part of the head. Only one fragment of the right half of the brain case was recovered —about two-thirds of the right parietal bone—but that is sufficient to give an exact basis for reconstruction of the whole skull. The right half of the mandible, we

may be certain, is a replica of the missing left half. With these cranial fragments and the associated animal remains and human implements, Sir A. Smith Woodward returned to his work-rooms in the British Museum (Natural History) early in the summer of 1912, and set himself to study their characters and their significance. About the end of the summer rumours of this remarkable discovery were circulating in the scientific circles of
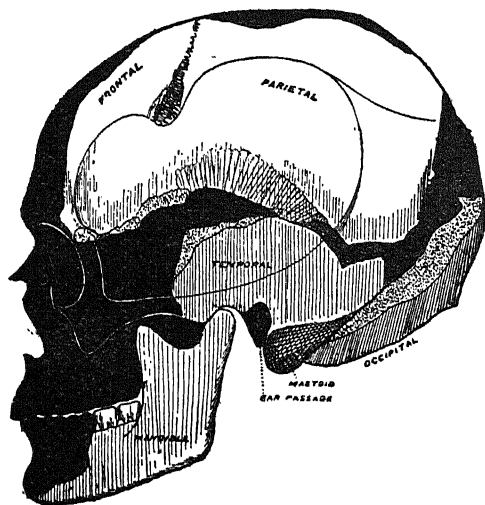
FIG. 170.—Outline of a modern skull to show the number and position of the cranial fragments recovered at Piltdown before 1913. The black areas represent missing parts.

London. The discovery, however, was not made public until 18th December 1912, when, at a crowded meeting of the Geological Society, Mr Charles Dawson and Sir A. Smith Woodward gave a clear and full account of one of the most remarkable discoveries of the twentieth century.

After the date of this meeting a vigilant search was maintained and further fragments of Piltdown man were recovered. In the summer of 1913, as we shall see, there was found in the gravel of the pit a canine tooth of the lower jaw, not of the usual human form but of the

pointed shape which occurs in anthropoid apes. Also bones of the nose—the two nasal bones—were found.

Then, early in 1915, Mr Dawson's search met with a further reward, not in the pit but on the surface of a field on the plateau two miles distant from the original site of discovery.[1] Mr Dawson had noted that this field, when ploughed and harrowed, was strewn with the dark brown angular flints of the fossiliferous stratum of gravel. After a tedious search he found three fragments, which certainly belong to the same human type as those which were discovered in the pit, namely, a fragment of the right side of the forehead, carrying the inner corner of the right orbit (fig. 251, p. 690), a fragment from the middle part of the occipital bone which forms the hinder part of the head, and a molar tooth of the left side of the lower jaw. All of these additions are of the greatest service in determining the nature of the earliest Englishman we know of as yet.

[1] "Fourth Note on the Piltdown Gravel, with Evidence of a Second Skull of *Eoanthropus dawsoni*," by Sir A. Smith Woodward, *Quart. Journ. Geol. Soc.*, 1917, vol. lxxiii. p. 1.

CHAPTER XXVII

THE ANTIQUITY OF THE PILTDOWN RACE

A GREAT company assembled in the rooms of the Geological Society of London on the evening of 18th December 1912, to receive the first authentic account of the discovery at Piltdown. An unknown phase in the early history of humanity was to be revealed; a revelation of that kind stirs the interest of many men, and draws them from their studies and laboratories to brave the heated atmosphere of overcrowded meeting-rooms. The various fragments of the skull had been pieced together; the missing parts had been filled in; a complete skull was thus brought before the meeting. It was quite plain to all assembled that the skull thus reconstructed by Sir A. Smith Woodward was a strange blend of man and ape. At last, it seemed, the missing form—the link which early followers of Darwin had searched for—had really been discovered. No one had ever suspected that a secret of this kind lay hid away in the Weald of Sussex. We shall attend the meeting of geologists, however, not so much to learn what kind of beings those ancient inhabitants of England were, as to ascertain their position in the scale of time—to see their place in the scheme of man's evolution. We want to hear from the lips of those who have studied the recent history of the earth, and who have discovered the sequence and the dates of more recent land changes and deposits, how long ago it is since these ancient people lived in the Weald of Sussex. We shall take, in the first place, the opinion of Sir A. Smith Woodward. In his judgment the Piltdown remains " are almost (if not absolutely) of

the same geological age " as the Heidelberg mandible—the oldest fragment of man's body yet found on the continent of Europe. The geological age of the Heidelberg mandible, as we have seen in a former chapter, has been fixed with some approach to accuracy. It was discovered in a deposit laid down in the ancient bed of a tributary of the Neckar near the beginning of the Pleistocene stage of the earth's history. The Cromer beds were in process of formation in East Anglia. Sir A. Smith Woodward's opinion, then, is that the Piltdown form of man was living in Southern England at an early part of the Pleistocene period, and that, at the same date, a very different kind of man was inhabiting Central Europe.

The reader may naturally break in with the question : How long ago is that ? The facts which will yield an estimate of geological time certainly exist, and in the opinion of men like Rutot, Sollas, and Penck are sufficient to afford an approximate estimate—the first step towards accurate figures. We shall take the estimate of Professor Sollas [1] first. He regards the deposits which were laid down during the Pleistocene period as forming, when superimposed, a thickness or depth of 4000 feet (see frontispiece). He estimates that the formation has proceeded at the rate of a foot per century, and that therefore the collective deposits of the Pleistocene period probably have taken about four hundred thousand years to form. The estimate given by Professor Rutot is much less—one hundred and forty thousand years. Short as it is, that estimate deserves our serious consideration, for it is founded on a prolonged study of the Pleistocene formations found along the river valleys of Belgium. There is a third estimate which must also weigh with us in coming to a conclusion as regards the duration of the Pleistocene period—that of Professor Penck.[2] He has studied the changes produced by Alpine glaciers during the Pleistocene cycles of extreme cold. He is of opinion that such changes indicate for the Pleistocene

[1] *Nature*, 1900, vol. lxii. p. 481.
[2] See A. Penck, *Zeitschrift für Ethnologie*, 1908, vol. xl. p. 390.

period a duration of at least half a million years, perhaps they may have occupied as much as a million and a half. These figures are mere provisional estimates, subject to modification as our knowledge increases. The numerous changes in climate, of elevation and depression of the land, the transformation of our animals, the elaboration of human culture, the evolution and distribution of human races, all bespeak an enormously long period of time.

To arrive at an estimate of the antiquity of the Piltdown remains, we must also allow for the time which has elapsed since the Pleistocene period ended and our present era began. There is now a general agreement that about ten thousand years would cover this recent period. When, therefore, Sir A. Smith Woodward assigns the Piltdown remains to an early phase of the Pleistocene epoch, we may, in the present state of our knowledge, suppose him to refer the Piltdown race to a time which passed, certainly one hundred thousand years ago, perhaps as much as five times this sum. There is a growing tendency amongst geologists to shorten the length of the Pleistocene period. Beyond any question, the Piltdown skull represents the most ancient human remains yet found in England.

Having thus attempted to give Sir A. Smith Woodward's opinion of the antiquity of the Piltdown remains in terms of years, we must again return to the meeting of geologists and take up the narrative there. The discoverer of the remains, Mr Charles Dawson,[1] said " he was quite prepared, from an anthropological point of view, to accept an earlier date for the origin of the human remains, and Dr Woodward and he had perhaps erred on the side of caution in placing the date as early Pleistocene." In Mr Dawson's opinion, then, it is possible that the Piltdown race may belong to the period preceding the Pleistocene—the Pliocene. Sir William Boyd Dawkins said " he agreed with the authors of the paper that the deposit containing the human remains belonged to the

[1] *Quart. Journ. Geol. Soc.*, 1913, vol. lxix. p. 151.

Pleistocene age, and that the Pliocene mammalia in it—
Mastodon arvernensis and the rest—had been derived
from a Pliocene stratum formerly existing in that area."
This opinion, coming from one who has the right to
speak with authority, must evoke surprise. When he
found the remains of the same species of Mastodon in the
Doveholes cave in Derbyshire in 1903, unaccompanied by
human remains, Sir William unhesitatingly assigned the
contents of that cave to the Pliocene period; but when
the same remains are found in Sussex, accompanied by
human remains, the deposit, in his opinion, should
be referred to a much later date. In Sir William's
opinion man is an evolutionary product of the Pleistocene
period, and first reached Britain about the middle of
this epoch. Much more guarded opinions were given
by Mr Clement Reid and by Mr A. S. Kennard,
who have made a special study of the later deposits
in the south of England. "It was impossible," said
Mr Reid, "to speak with confidence, but the whole
evidence suggested that the Piltdown deposit and the
plateau on which it rests are not preglacial or even early
Pleistocene; they belong to a period long after the first
cold period had passed away, but they occur at the
very base of the great implement-bearing succession of
Palæolithic deposits in the south-east of England."
Mr Kennard regarded the Piltdown gravel as being of
the same age as the 100-foot terrace of the Thames
valley, which, as we have already seen, is made up of
strata belonging to various stages of the Pleistocene
epoch. Mr Kennard's opinion is of the greatest interest,
because it was from the 100-foot terrace of the valley of
the lower Thames, at a depth of 8 feet, in 1888, that a
human skeleton was found at Galley Hill. If Mr
Kennard is right, the Galley Hill man, who was of the
same type as modern man, must have been almost con-
temporaneous with the very primitive human being
which Sir A. Smith Woodward had reconstructed from
the Piltdown fragments. Mr E. T. Newton, who, in
1896, brought the Galley Hill discovery before the same

Society as now discussed the Piltdown find, was also present. It must have puzzled him to explain why the audience, which in 1896 refused to accept the Galley Hill discovery, because the remains were those of a being framed much as we moderns are, should extend so ready an acceptance to the very simian form of man which had been raised from the Piltdown fragments. Here we are concerned only with the opinion Mr Newton formed of the antiquity of the Piltdown remains. To him, " the highly mineralised condition of the specimens seemed to point to their being of Pliocene age rather than Pleistocene."

We must also note the opinion of the leading authority of France—Professor Marcellin Boule. He agrees with Mr Kennard in regarding the Piltdown gravels as of the same age as the 100-foot terrace, and while in his text he assigns Piltdown man to the time of Chellean culture, yet in the table, where the succession of Pleistocene men is shown, Piltdown man is placed later than Heidelberg man, being made to coincide with the earliest age of Acheulean culture.[1]

The writer is a student of the human body, and is therefore not in a position to offer any conclusive evidence which will help to settle whether the Piltdown man was Pleistocene or Pliocene. Yet there is one point which must weigh with those who seek to place this newly discovered human form in its proper place in the scale of time. The lower jaw, especially in the region of the chin, is marked by certain characters which separate it sharply from the corresponding part of all human mandibles and link it closely with the jaw of apes. Even in the Heidelberg mandible, which belongs to the early Pleistocene age, the essential features of humanity are already evident. In the Piltdown mandible the conformation is that of the ape ; a simian stage is still preserved. The Heidelberg mandible shows that the human contour of the chin had already appeared at the beginning of the Pleistocene, but a change of this kind has not become

[1] *Fossil Men*, translated by Jessie and James Ritchie, 1923.

manifest in the Piltdown mandible. This feature suggests that Piltdown man represents, as the animal remains accompanying him suggest, a Pliocene form. I am of opinion that future discoveries will prove that the remains found at Piltdown represent the first trace yet found in Europe of Pliocene man.

The reader may feel by the time he has reached this point that enough has been said about the time at which the Piltdown man lived. Probably he is already wearied with the clash of expert opinion. Yet the differences are perhaps not so great as they appear. It will be remembered that Mr Lewis Abbott, who has given as much time as anyone to master the later geological history of the Weald, expressed the decisive opinion that in the Piltdown gravel two ages are represented. The lower or bottom stratum, which contained the Pliocene remains and human bones, is, in Mr Abbott's opinion, Pliocene in date; the upper levels, in which the rude Palæolithic implements lay, have been disturbed at a later time, and are to be regarded as Pleistocene in age. If Mr Abbott is right, and a survey of the full evidence favours his inference, then the divergence of opinion is explicable : those who maintain that the Piltdown gravel is Pleistocene are right, and so are those who regard it as Pliocene. Indeed, in a subsequent communication Mr Dawson wrote of the " dark " or Eoanthropus stratum as follows : [1] " We cannot resist the conclusion that the third or ' dark ' bed is, in the main, composed of Pliocene drift, probably reconstructed in the Pleistocene epoch. . . . Putting aside the human remains and those of the beaver, the mammalian remains all point to a characteristic fauna of Pliocene age; and, though all are portions of hard teeth, they are rolled and broken. The human remains, on the other hand, although of much softer material, are not rolled, and the remains of the beaver are in a similar condition."

So far we seem to have gone a long way merely to reach the conclusion that the Piltdown man is possibly

[1] *Quart. Journ. Geol. Soc.*, 1914, vol. lxx. p. 85.

of Pliocene age. To assign even the remains of man to the Pliocene period carries but a shadowy significance to most of us. If, however, we again visit Piltdown and survey the changes which have occurred in the Weald since fossil man was living there, we obtain some insight into his great antiquity. Mr Dawson discovered and delimited the remains of a great sheet of gravel which, in former times, covered the Piltdown plateau. The sheet apparently extended (see fig. 167) for about twelve miles in one direction and eight in another, and must have formed a great deposit for such a small stream as the predecessor of the Sussex Ouse to lay down. Only some patches and pockets of the original deposit have come down to us. The plateau is now 120 feet above the level of the sea, but it is probable that it lay almost at sea-level when this great sheet was being deposited. The formation of so extensive a gravel bed must have occupied a long space of time, for the oldest or bottom layer is apparently Pliocene in date—the upper or disturbed layer is much later, probably middle Pleistocene in age. Over this wide Pliocene plain the ancient Ouse had meandered, shifting its bed from time to time and laying down gravel, sand, and fossil remains, gathered on the higher lands of the Weald. The present Ouse has cut a valley, 80 feet deep, in the plateau. This valley has been excavated since the time the more recent gravel beds were laid down on the plateau. How often the valley has been re-excavated, as the land rose ; how often it has been filled up, as the land sank, we cannot as yet tell ; certainly the valley of the Ouse rose and fell with that of the Thames. But it is clear that there have been many variations in the level of the land since the gravel was first laid down on the Piltdown plateau. The human remains lay in the most ancient gravel deposit. Since the Piltdown man lived, then, the great expanse of gravel, measuring nearly one hundred square miles, has been laid down and a valley, at least 80 feet deep, has been slowly eroded by a comparatively small stream. As the first gravel was being laid down the culture of man was represented by

flints worked in a pre-Chellean style and surprising pieces of bone work. And long before Piltdown days there had been the men who shaped eoliths. As things are to-day, man's culture is represented by the wireless messages and aeroplanes which cross the Weald, and the great steamers passing down the Channel, and the rural homes and country houses which everywhere meet the eye.

No one suspected, until Mr Dawson made the discovery, that deposits of a Pliocene or early Pleistocene
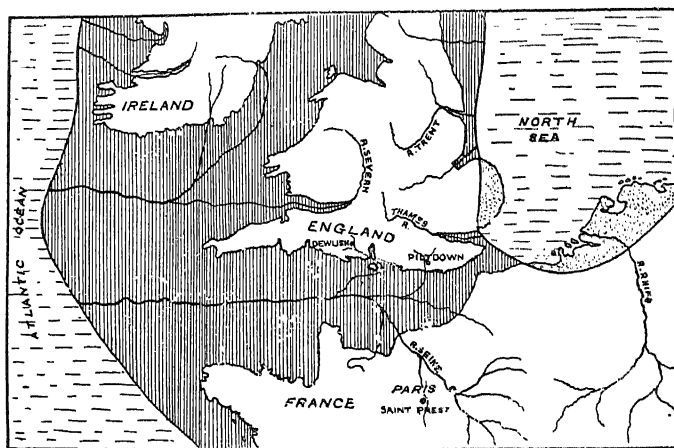
FIG. 171.—Map of South England and North France, to show the course and tributaries of the ancient channel river. (After Boyd Dawkins.)

date occurred in the Weald of Sussex. It is not likely that Piltdown is the only site at which such deposits occur in the region of the English Channel. If one looks at a map representing the bounds of England during the great land elevation in late Pliocene times—the date at which Piltdown man or his ancestors may have lived—it will be seen (fig. 171) that in place of the English Channel there is a great river which is joined by all the streams issuing from the southern area of the Weald. It will be seen, too, that the Somme and the Seine also lie within the watershed of the great channel river. Now on a tributary of the Seine is situated St Prest,

near which there is, as M. Rutot has indicated, a deposit very similar in nature and in age to that at Piltdown. We have already seen that the deeper strata of gravel at St Prest contain remains of Pliocene animals and have always been regarded as of a Pliocene age (see fig. 114, p. 317). Over the Pliocene beds are others of a later or Pleistocene age, just as at Piltdown. So long ago as 1863, M. Desnoyers [1] recognised that many of the fossil bones of animals existing in the Pliocene period, and found in the deepest and oldest deposits of St Prest, showed definite evidence of having been worked by man. More striking still, the land on which these deposits occur is 80 feet above the adjoining tributary of the Seine, the Eure—the same height as the Piltdown deposits lie above the Ouse. The Pliocene age of the St Prest deposits has never been called in question.

There is a further striking similarity between the deeper deposits at St Prest and the dark bed at Piltdown. Mention has been made of the eoliths which occurred with the human remains in the dark bed. Shaped flints of a corresponding type also occur in the Pliocene beds at St Prest. They were discovered and described by a geologist, M. Bourgeois,[2] in 1867, four years after M. Desnoyers recognised the human markings on the fossil bones. In M. Rutot's opinion the St Prest implements are of a later and more highly evolved type than the Kentish eoliths. The discoveries made at St Prest fifty years ago have a very direct bearing on the problem of the age of the Piltdown remains.

The evidence of another Pliocene deposit may be cited here. In the south of England, about one hundred miles to the west of Piltdown, but still within the watershed of the old Channel river, there occurs another trace of the Pliocene period which is of the greatest importance to the student of man's evolution. This trace occurs at Dewlish, a small village in the chalky

[1] M. J. Desnoyers, *Compt. Rend.*, 1863, vol. lvi. p. 1073. See also references given on p. 317.

[2] See *Paléontologie humaine*, by E. T. Hamy, Paris, 1870, p. 98.

uplands of Dorset (fig. 171). Near the village of Dewlish the chalk plateau, about 300 feet above sea-level, ends in a sharp bank or escarpment, about 100 feet in height, similar to the chalk brim of the Weald. On this plateau, near Dewlish, there was discovered by accident a deep fissure in the chalk which was filled with layers of sand and gravel. This fissure or trench was investigated by the Rev. O. Fisher, and has been described by him in two communications to the Geological Society of London.[1] It was found to be over 100 feet in length, with one end open on the free face of the escarpment. Its depth was found to be over 12 feet. It was narrow and filled in with sand and gravel, which do not now occur on the surface of the plateau at Dewlish. In the gravel were found remains of elephants of the ancient kind found at St Prest and at Cromer—*Elephas meridionalis*—which is accepted as a true representative of the Pliocene period. In the gravel also occurred certain flints which were regarded by Mr Grist [2] as similar to the eoliths of the Kentish plateau. Mr Clement Reid inspected the trench —the only one of the kind known—and formed the opinion that it did not represent any cleft or fault produced by natural agencies. No stream could have produced such a trench ; there is no stream now on the plateau. Mr Fisher could only account for it on the supposition that it was dug by the hands of man, and was designed, like similar trenches at the present day, as an elephant trap. If Mr Fisher's inference is right, and no other satisfactory explanation has been offered, we have the startling revelation that in the Pliocene period mankind had already reached an advanced stage in his evolution. And those opinions were formed and expressed years before Mr Dawson had found a bone implement at Piltdown, apparently worked from the thigh bone of

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[1] *Quart. Journ. Geol. Soc.*, 1888, vol. xliv. p. 819; 1905, vol. lxi. p. 35. Since the above was written, the Dorset Field Club has reopened the trench. The evidence favours natural—not a human—formation.

[2] C. J. Grist, " Some Eoliths from Dewlish, and the Question of Origin," *Journ. Roy. Anthrop. Inst.*, 1910, vol. xl. p. 192.

the kind of elephant whose fossil remains occur in the trench at Dewlish.

We have already mentioned the sub-Crag implements discovered by Mr Reid Moir (p. 308). They indicate the existence of human beings towards the middle of the Pliocene period. The Kentish eoliths are more ancient than the sub-Crag implements.[1] When, therefore, we take into consideration these facts, and the similarity between the Piltdown and St Prest deposits, we are persuaded that Mr Dawson and Sir A. Smith Woodward were ultra-cautious in assigning a Pleistocene date to the human remains found at Piltdown. All the evidence seems to point to a Pliocene age—to an age at least as old as the Cromer forest bed. Hence the importance of their discovery, for although the handiwork of Pliocene man has been recognised for a considerable number of years, the man himself was unknown until Mr Dawson brought the Piltdown type into the light of day.

[1] J. Reid Moir, *Nature*, 1924, vol. cxiii. p. 461.

CHAPTER XXVIII

EOANTHROPUS DAWSONI

HAVING thus settled, so far as the evidence will permit, the approximate position of the Piltdown man in the scale of time—and beyond question he represents the earliest specimen of true humanity yet discovered—we now proceed to see what sort of being he was. The truth is that we have to discover his characters from fragments of the skull, for no other part was found. The form of his limbs and body are matters of inference. The reader will quickly realise the number and size of the actual parts of the skull which were found, by examining fig. 172; the missing parts are indicated by stippled lines. The bone which forms the forehead—the frontal bone—is only partly present. Fortunately, the region which forms the upper margin of the left orbit has been preserved in its outer part, so that we can form a definite opinion as regards the supra-orbital ridges. These are not formed as they are in the chimpanzee, gorilla, Rhodesian and Neanderthal man, but are more like the conformation seen in modern human races. A great part of the left side of the frontal bone has been recovered; the right side is wholly missing, but we know that the right and left sides of the frontal bone are nearly symmetrical, so we can reconstruct the greater part of the forehead with some degree of assurance—all except the middle part lying over the root of the nose. This initial blank in our knowledge was also made good, for the fragment of the frontal bone, found by Mr Dawson in 1915, gave us the contour of parts above the root of the

nose and showed that in the modelling of his forehead
Piltdown man resembled living man.

Taking the bones which form the roof of the skull just
behind the frontal bone, we see that practically the whole
of the parietal bone is present on the left side. It forms
the roof and side of a great part of the brain chamber,
and is therefore of the utmost importance. We want
especially to know about the brain, for this is the master
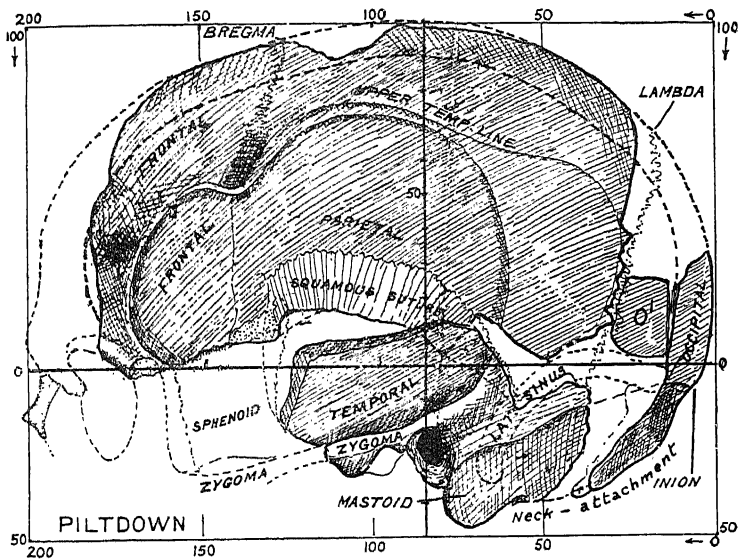
FIG. 172.—Fragments of the Piltdown skull placed in position and
represented in profile.

organ of the human body. It will be noted that even on
the left side certain fragments of the parietal bone are
missing along its upper margin, hinder border, and at its
lower angle behind. The dimensions of these missing
parts can be estimated with accuracy. The parietal bone
of the opposite or right side is also represented. Only
about two-thirds of that bone is present, and, un-
fortunately, the part which is missing is the upper area
which reaches up to the middle line on the roof of the
skull, where it should come into contact with the opposite
or left parietal bone. The actual part of the right

parietal bone recovered is indicated in fig. 173, where it has been superimposed over the corresponding area of the left side.

Coming now to the hinder or occipital end of the skull, we find the bone of this region represented by a considerable fragment. The part of the occipital bone is
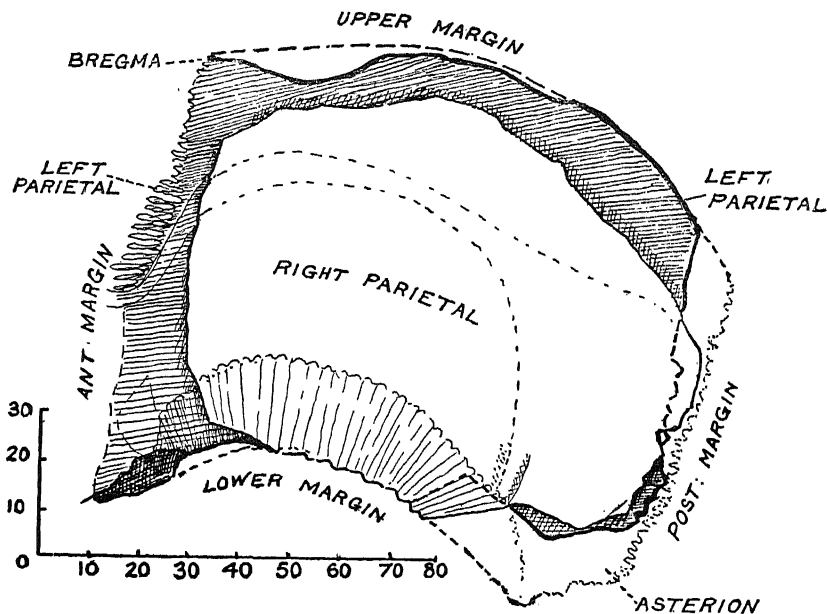
FIG. 173.—A reversed or mirror-image of the fragmentary right parietal bone of the Piltdown skull superimposed on the corresponding points of the bone of the left side, to show the extent of the parts missing from each.

best seen in a hinder view of the skull such as is shown in fig. 174. To the lower part of the occipital bone the neck is fixed; part of the region for the fixation of the neck is represented in the fragment found (fig. 172). At the lower end of the fragment is seen the hinder margin of the foramen magnum, by which the spinal cord makes its exit from the brain cavity to enter the spinal column. The tabular part of the occipital bone, which rises up from the neck to form the projecting hinder

part of the head, has also an important representation. By great good fortune, Sir A. Smith Woodward recovered a most essential fragment of the right half—the fragment which gives us an indication of the width of the occipital bone, almost up to its articulation or point of contact with the right parietal bone (see figs. 172 and 174, O'). On the occipital bone the ridge which marks the middle

PILTDOWN RECONSTRUCTION
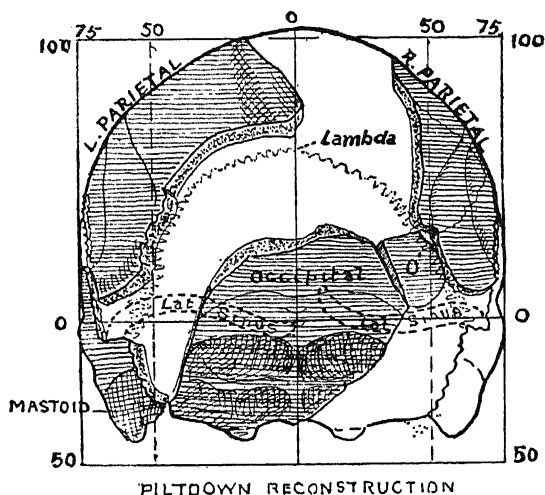
FIG. 174.—The fragments of the Piltdown skull viewed from behind. The fragment of the occipital bone, marked O', is that found by Sir A. Smith Woodward. Above it is seen the hole made by the blow of the pick which detached this fragment from the parietal. I have left a narrow triangular gap between this fragment and the main occipital bone because an examination of the original specimen led me to think a splinter is missing. Compare with fig. 190, B, where a reconstruction is given with fragment O', in the position assigned to it by Sir A. Smith Woodward.

line of the head and of the neck is preserved (fig. 174). We therefore know the width of the right half of the occipital bone, and we may be certain the left half was almost exactly of the same size. Hence in the drawing (fig. 172) of the recovered fragments the right half of the occipital bone is represented as if it were on the left side, in place of the right.

The frontal, parietal, and occipital bones form the front, roof, and hinder part of the brain chamber. The

temporal bone, which helps to complete the lateral wall of the chamber, also forms part of the floor or base of the cranial cavity. Almost the whole of this bone was found —of the left side (fig. 172). A fragment is missing, but sufficient of its upper border is preserved to give us its true relationship to the parietal bone. As may be seen in fig. 172, a mutual point of contact is present on the opposing margins of the temporal and parietal bones. It will thus be realised that all the essential components of the brain chamber are present ; there are sufficient parts to form almost a complete half of the brain chamber. In the case of the skull a half is almost as good as a whole, for the left and right halves of every head are approximately similar.

All of these fragments of the Piltdown skull are, at first sight, very similar to the same parts of a modern human skull except as regards their thickness. The Piltdown bones are surprisingly thick. The farm-labourer who first saw the skull described it as a coco-nut. In most modern heads the thickness of the bones forming the brain chamber varies from 4 to 6 mm. ($\frac{1}{6}$ to $\frac{1}{4}$ of an inch) ; in native African races, and occasionally in Europeans, the thickness may amount to 8 or even 10 mm., but in no normal modern skull are all the bones so uniformly thick as in this recently discovered specimen. As already pointed out, the ancient skulls found at Galley Hill, Clichy, and Olmo are thick, but not to the extent seen in the Piltdown fragments. Thickness is also characteristic of most Neanderthal skulls. In the Piltdown cranium the frontal, parietal, occipital, and temporal bones vary in thickness from 8 to 12 mm., the average all over being about $\frac{2}{5}$ of an inch. The bone is naturally formed ; there can be no question of disease. The late Professor Shattock definitely settled this point.[1] There can be no doubt that sufficient of the skull has been recovered to provide us with the means of reaching a just and certain conclusion as regards the size

[1] See *Proc. Internat. Med. Congress*, London, 1913 (Pathological Section).

and shape of the part which contains the brain. Very few ancient skulls are so well represented as that of Piltdown.

The discovery of almost a complete half—the right—of the lower jaw or mandible by Mr Dawson is a most fortunate circumstance (fig. 175). It lay in the iron-stained cemented stratum with unworn eoliths and a fragment of the tooth of an early Pliocene form of
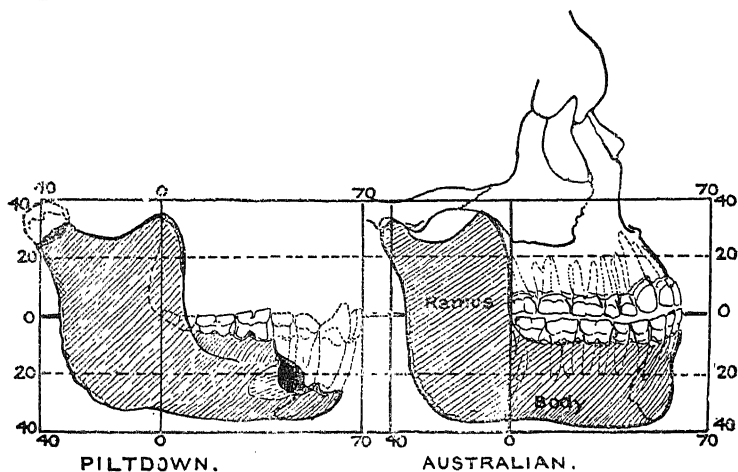
FIG. 175.—The Piltdown mandible, as seen in true profile, compared with a corresponding view of the mandible of an Australian native. The missing teeth and parts of the Piltdown mandible are indicated by stippled lines.

elephant. The importance of the mandible is at once apparent; it provides us with the skeletal outline of the face of this ancient form of man. Each half of a human mandible consists of two distinct parts: (1) a horizontal part or body (fig. 175), which carries the teeth and forms the lower part of the outline of the face—from the angle of the jaw below the ear to the chin; (2) a vertical part, which ascends from the angle to terminate in an articular knob or condyle. The socket—the glenoid cavity—for the articular knob is situated on that part of the base of the skull which is formed by the temporal bone immediately in front of

the ear. We have already seen that the temporal bone of the left side was recovered, revealing the characters of the articular cavity, which is shaped exactly as in modern races, and in this respect quite unlike the same joint in an ape's skull. In the Piltdown skull we have thus the greater part of one-half of the mandible of the right side ; on the left side the articular socket for the jaw is present ; by transposing or reversing the right half of the mandible to take the place of the left half, it will be seen that we obtain a representation of the skeletal outline of one-half of the Piltdown head (see fig. 252, p. 691).

Unfortunately, a fragment is missing from each part of the right half of the mandible (fig. 175). All of the ascending part is present ; the areas for the attachment of the chewing muscles are intact, save the articular knob itself. This is no great loss, because the shape of the socket in which it plied is known to us, and as that socket, although large, is shaped as in present-day man, we may presume the articular knob or condyle of the jaw also had a modern human form. The part missing in the body or horizontal part of the jaw leaves some room for speculation. That region of its upper border which lies hidden behind the lower lip in life, and carries the sockets of five teeth—the two right incisors, the right canine, and two right premolar teeth— has been broken away. The part which bears the three molar teeth is present ; the first and second molar teeth fill their sockets, but the third or wisdom tooth had dropped out after death. The deficiency thus affects the upper or alveolar border of the jaw in front ; the whole of the lower border of the body of the mandible is present. As the body approaches the region of the chin (see fig. 238) it becomes modelled in a form which is peculiar to apes.

Early in the summer of 1912, when Sir A. Smith Woodward commenced his examination of the Piltdown fragments, he realised that the peculiar and characteristic features of this ancient form of man were centred in the

region of the chin. Such features had never been found nor seen in any mandible or skull to which the term human could be applied. The peculiar characters of the chin, which arrested his attention, can best be realised by a reference to such illustrations as are shown in figs. 176 and 177. In fig. 177 is represented the arrangement of parts seen in the chin region of a young chimpanzee—about four years of age, just before the milk teeth are shed. When a section is made so as to separate the lower jaw and the tongue into right
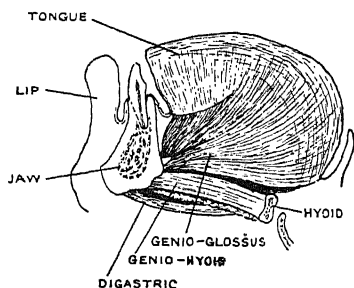
MAN.

FIG. 176.—Section of the human tongue, chin, lower jaw, and lip made along the middle line, to show the origin of muscles from the region of the chin or symphysis.
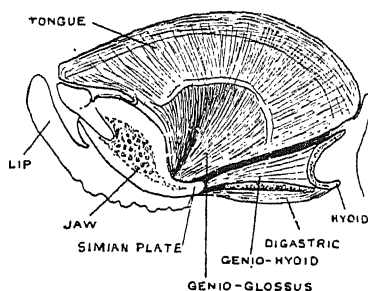
CHIMPANZEE.

FIG. 177.—A corresponding section of the same region of a young chimpanzee.

and left halves, it is seen that the jaw in the region of the symphysis—the line of fusion of the right and left halves of the jaw—is composed of two parts, an upper part to bear the incisor teeth, and a lower part which is for the attachment of muscles. It is the lower or muscular part which principally concerns us. There is no projection of the anterior surface at the lower border of the symphysis to represent a chin in the chimpanzee; the anterior or labial surface of the jaw slopes downwards and backwards to a chinless lower border. On the hinder surface of the symphyseal region—the surface directed towards the tongue—there is seen a deep pit, almost large enough to take the tip of the little

finger. From the interior of the genial pit arise the two chief muscles of the tongue—the genio-glossus muscles. The lower margin of the pit is formed by a plate of bone—the simian plate—which unites the lower borders of the right and left halves of the jaw (fig. 177). It is a strengthening plate. From the posterior margin of the plate two pairs of muscles take their origin—the genio-hyoid muscle, which draws the larynx forward during the act of swallowing, and the digastric muscle, which depresses the front part of the jaw, and thus assists in opening the mouth. Such is the conformation of the symphyseal or chin region of the lower jaw in apes (see fig. 177).

When a corresponding section is made of the symphyseal region of a human lower jaw, a very different conformation is seen (fig. 176). There are the same two parts exposed in the section—the upper dental part, which carries the incisor teeth, and a lower part for the attachment of muscles. The dental part, compared with that of an ape, is small and vertical in direction. The human teeth being relatively small, the dental part of the jaw has retreated backwards in the mouth. The muscular part, on the other hand, has been advanced; there is now a prominent, or, at least, a well-marked chin. The genial pit and simian shelf seen in the ape's jaw are absent. In place of rising from a pit, the main muscles of the tongue—the right and left genio-glossus—arise from an elevation of bone bearing two tubercles. The genio-hyoid, in place of rising from the upper margin of the shelf of bone, springs from the lower part of the elevation which has filled up and replaced the pit, while the digastric muscles are attached to the lower border of the jaw just behind and below the chin.

It will thus be seen that the simian and human mandibles differ markedly in the region of the symphysis or chin. The meaning of this difference will be discussed in a later chapter (p. 659). As to the type to which the Piltdown jaw belongs there can be no doubt; both the genial pit and the simian plate are present. These are ape-like

features. Sir A. Smith Woodward recognised them as such, and in his work of reconstructing the original form of the skull the presence of these simian features exercised a dominating influence. Hence, when he came to replace the missing parts of the jaws and the incisor and canine teeth, he followed simian rather than human lines. The teeth of man form a uniform series ; there is no break nor diastema in front of, or behind, the canine teeth ; the canine tooth does not project prominently beyond its
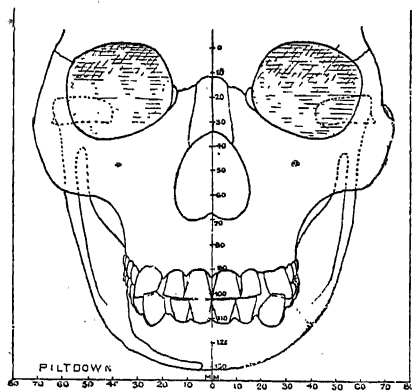
FIG. 178.—The muzzle and front teeth of the Piltdown skull as originally reconstructed by Sir A. Smith Woodward.
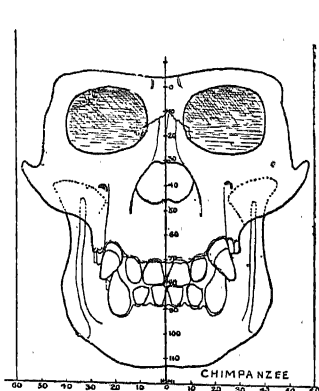
FIG. 179.—Similar view of the same part of a male chimpanzee.

fellows. From the ape-like features of the chin it was inferred that projecting simian canine teeth must have been a characteristic of the Piltdown form of man. A massive canine tooth was therefore modelled ; not very projecting (see figs. 178, 180), thick and rather stumpy, its longest or front-to-back diameter being 14·5 mm., its side-to-side, 10 mm. The diameters of such a tooth are equal to those of the canine of a male chimpanzee, and far beyond the limits of the largest human canines known. As in the chimpanzee, a break or interval in the dental series was left both in front of and behind the canine. The width and conformation given to the front or incisor teeth were those of the chimpanzee ; when the Piltdown

lips parted one would have seen the ferocious dental array of the anthropoid (figs. 179, 181). As regards the rest of the teeth—the two premolar and three molar—man's dentition rather than the chimpanzee's was copied. The first and second molar teeth were found actually in the jaw; they were not larger than the corresponding teeth of certain modern races, and are distinctly human in pattern—at least more human than anthropoid. The premolars had to be made much larger than in human jaws, but they were given a human not a simian form. Thus in the first reconstruction of the Piltdown skull there appeared to be a mixture of dentitions. In front the teeth were simian; behind they were human.

We are dealing at present with the parts which were actually found when the discovery was first announced. In the autumn of 1913 a canine tooth was discovered which must be assigned to the Piltdown mandible. It was, as Sir A. Smith Woodward had anticipated, essentially simian in form—it was more like that of a female chimpanzee or gorilla than that of a human being. By the time this tooth was discovered I had come to the conclusion, for reasons which will be given in another chapter, that a massive human and not a projecting and simian canine had really been present. In that I was mistaken, but as regards the actual dimensions of the tooth my estimate was approximately right. I allowed 10 mm. for the longest (front-to-back) diameter; it proved to be 11 mm. Sir A. Smith Woodward had represented it as 14.5 mm. In the chief point, however, Sir A. Smith Woodward was right; the simian chin was correlated with a simian canine tooth.

As will be seen from figs. 178 and 179, Sir A. Smith Woodward made the muzzle and front teeth of Eoanthropus wider and more massive than in the chimpanzee. He made the region of the chin and symphysis—the anterior line of fusion of the two halves of the mandible—particularly strong (fig. 180). The symphyseal areas of union or fusion between the two sides of the mandible are stippled in figs. 180 and 181. In the Piltdown man-

dible this area, as restored by Sir A. Smith Woodward, is even greater than in the chimpanzee. While the teeth implanted in the front part of the mandible and the symphyseal region are truly simian, the hinder part of the mandible, the molar teeth, and also the ascending branch or ramus, are, to my eye, entirely human. We have thus in this newly discovered form of man a remarkable mixture of simian and human characters.

One other feature may be pointed out here. It will
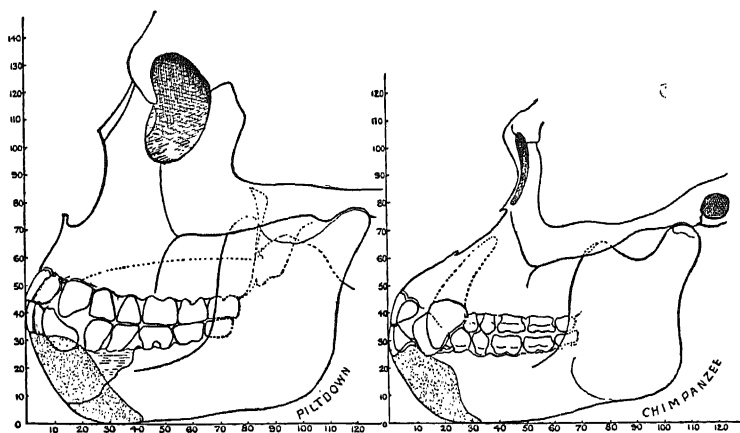
FIG. 180.—Drawing of the jaws, in profile, from Sir A. Smith Woodward's original model of the Piltdown skull.

FIG. 181.—A drawing of the same parts of a male chimpanzee.

be observed in fig. 175 that the greater part of the last molar or wisdom tooth lies behind the anterior margin of the ascending ramus of the jaw, being thus hid from view. In the Australian jaw (shown in the same figure), as is usually the case in man and apes, this tooth lies wholly in front of the ramus and is freely exposed. The Piltdown ascending ramus is remarkably wide (44 mm.), and its width is evidently due to a forward extension of its anterior border. On the anterior border is inserted the temporal muscle, the chief agent in biting or in suddenly shutting the lower jaw. Such a forward extension of the ramus must give the temporal muscles greater power

and purchase over the front part of the jaws and canine teeth.

It is necessary to examine in more detail the original reconstruction of the apparatus of mastication in the Piltdown man. Our estimate of the position of any newly discovered form of human being turns largely on the relationship between his alimentary and cerebral systems. It seems fairly certain that the tendency in human evolution is to increase the work of the brain and diminish the work of the stomach. An increase of brain power has made the task of our digestive system easier— at least those parts which are concerned in mastication.
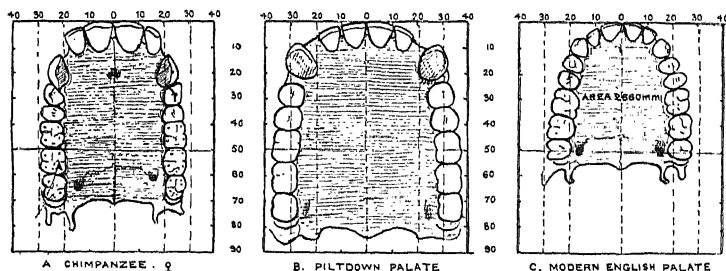
FIG. 182.—A comparison of the palatal areas in a female chimpanzee (A), in the Piltdown specimen as reconstructed in the original model (B), and in a modern Englishman (C).

We therefore need some means of indicating—even if the method adopted be but a rough approximation to the truth—the relative development of cerebral and alimentary powers in any newly discovered form of human being. We may take a concrete example. In fig. 182 is represented the palate of a female chimpanzee; the teeth are set round the circumference of the palate. Within the semicircle of teeth lies the tongue, but the whole area of the palate, all that lies inside the outer margins of the teeth, is directly concerned in mastication, and the total area of the palate may therefore be accepted as the degree to which the apparatus of mastication has been developed. We suppose that a large palate means a crude and not a richly nutritious diet. Now, in this female chimpanzee the area of the palate is 36·5 cm.^{2};

the brain measured 320 c.c.; there was 1 cm.² of palate to 8·7 c.c. of brain; this represents a common palato-cerebral ratio amongst man's nearest allies—the anthropoid apes. In modern Englishmen—my estimate is founded on an accurate investigation of twenty-two medical students—the average palatal area is 26·6 cm.²; the cerebral development, 1500 c.c.; the palato-cerebral ratio was therefore 1 : 56·3, in place of 1 : 8·7 as in anthropoids.[1] We therefore turn with some interest to see what ratio may hold in this newly discovered form of man. Sir A. Smith Woodward has reconstructed the palate. Accurate indications as to its shape were available as soon as he had obtained the form of the lower jaw and teeth, for the upper and lower jaws must fit and the teeth correspond in all higher animals, according to certain definite laws. Now the area of the palate thus reconstructed (see fig. 182, B) is 53·20 cm.²—larger than in the female chimpanzee; it is the size of palate seen in the adult male chimpanzee. In the male adult orang and gorilla the palatal area may reach 70 cm.². Sir A. Smith Woodward at first estimated that the brain capacity of Eoanthropus was about 1070 c.c. In this new form of man the palato-cerebral ratio is therefore about 1 : 20. This ratio holds an intermediate position between that of the chimpanzee (1 : 8) and that of modern Englishmen (1 : 56). We appear, therefore, to be dealing with a very primitive form of man—one which, so far as concerns its development of palate and of brain, supplies us with a stage half-way between ape and man. In modern native races the palato-cerebral ratio may be as low as 1 : 36·7. In the Gibraltar skull, as we have seen,[2] the ratio is 1 : 38. In Rhodesian man this ratio is 1 : 31·7; in La Chapelle man, 1 : 41·8.

We have already noted that the front teeth of this new form of man and the region of the chin are essentially

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[1] A later investigation of a larger series of English skulls has shown me that 26·6 cm.² is an overestimate. As measured in English male skulls the mean palatal area is 25·00 cm.².

[2] See p. 215.

ape-like—quite different from those of any known form
of human being.   The humanity of this being, however,
becomes more and more apparent as the mandible is
followed backwards and upwards to its socket at the base
of the skull.   The socket is robust and massive, but its
conformation is absolutely that seen in the more primitive
of modern human races.   When Sir A. Smith Woodward
came to fit the fragments of the skull together, he found
that the parts were human in form and must be fitted
together as in modern human skulls.   The shape which
the reconstructed head of Eoanthropus took in his hands
is shown in a series of figures (figs. 183, 185, and 188).
Students of anatomy will at once recognise the peculiar
features of this newly discovered type of man ; but in
order that those who have not made a special study of
man's body may also have a standard for comparison,
corresponding drawings of the skull of a modern English-
man are reproduced for comparison.   The Englishman
chosen has a brain capacity of 1425 c.c.—60 less than the
average amount.   The walls of his brain case have an
average thickness of 6 mm., whereas in Eoanthropus the
thickness is quite 10 mm. along the vault.   Both skulls
have been poised on the same horizontal plane—one
which approximately indicates the lower limits of the
cerebrum.   The higher or cerebral part of the brain lies
above the line on which the skulls are oriented.[1]   In the
modern head (fig. 189) the roof of the skull almost reaches
the 100-mm. line ; in Eoanthropus it passes slightly above
the 90-mm. line.   When we allow for the great thickness
of the skull, it is plain that the brain of Eoanthropus
will fall—as regards height—about 15 mm. ($\frac{2}{5}$ inch) short
of the modern English brain.   As regards the total
length of the skull, the ancient and modern man are
much alike—the maximum length in each case being
about 190 mm.

It is clear from these diagrams that the face of Eoan-

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[1] For details concerning this line or plane—the subcerebral plane—see
an article by the author in *Journ. of Anat. and Physiol.*, 1910, vol. xliv.
p. 251.

thropus is much more massive than that of modern man. As regards details of head conformation they have much in common. In both a prominent mastoid process lies behind the ear-hole ; it is shaped in the Piltdown man as in modern human races. As the mastoid is one of the
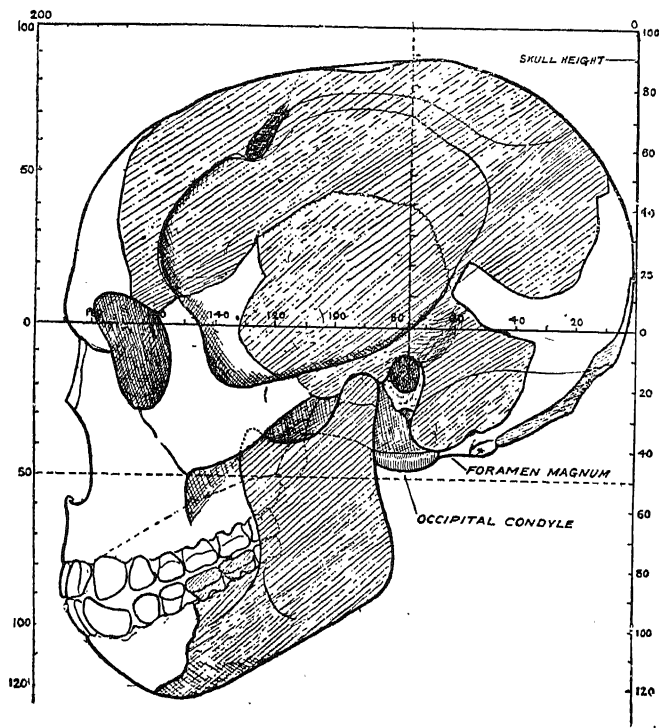
FIG. 183.—Profile drawing of Sir A. Smith Woodward's first reconstruction of the skull of Eoanthropus (half natural size). The parts present are shaded ; the missing parts are left blank.

structures by means of which the muscles of the neck move and balance the head, we must infer, from the fact that this process is present in its modern shape in Eoanthropus, that the head in that ancient type of man was carried and balanced just as it now is in us. The eye-socket of Eoanthropus will be seen to be set obliquely ; when the skull is viewed in true profile, more of the orbit is then to be seen than in modern human races, and much

more than in anthropoid apes. Above the outer angle
of the orbit it will be seen that the temporal line or crest
—from which a muscle of mastication arises—ascends
steeply on the frontal bone, whereas in all modern human
skulls the curvature is less acute and its backward trend
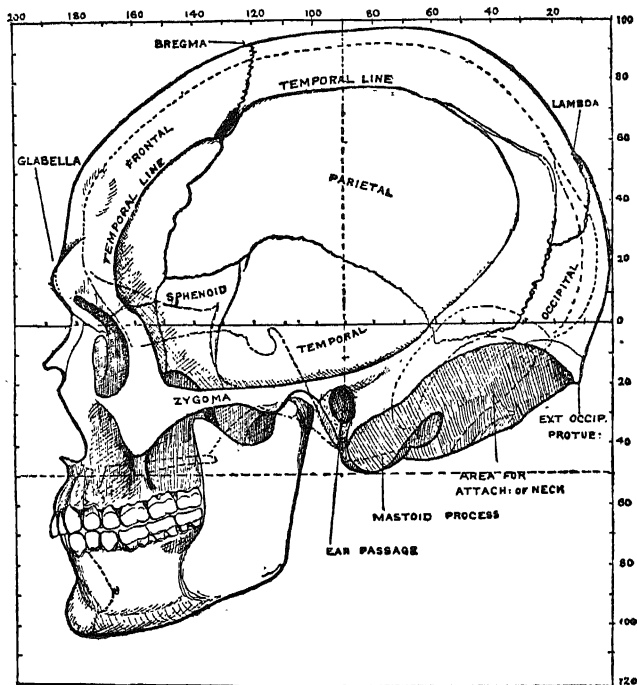
FIG. 184.—Profile drawing of the skull of a modern Englishman
with a cranial capacity of 1425 c.c. (half natural size).

more marked (see figs. 183, 184). The muscles of masti-
cation evidently did not work exactly as in modern man,
or why this difference in the conformation of the temporal
crests ?

When a full-face drawing of the skull of Eoanthropus is
compared with that of a modern skull (figs. 185, 186) a
number of differences become apparent. In width, both
at the base of the skull and across the cheek bones,
Eoanthropus is considerably the greater. The usual width

of the modern skull at its base is 132 mm. ; in Eoanthropus the width here measures 150 mm. The chief difference, however, lies in the filling of the brain case. In the modern skull the sides are nearly vertical, with a slight outward bulge half-way to the vertex ; in Eoanthropus
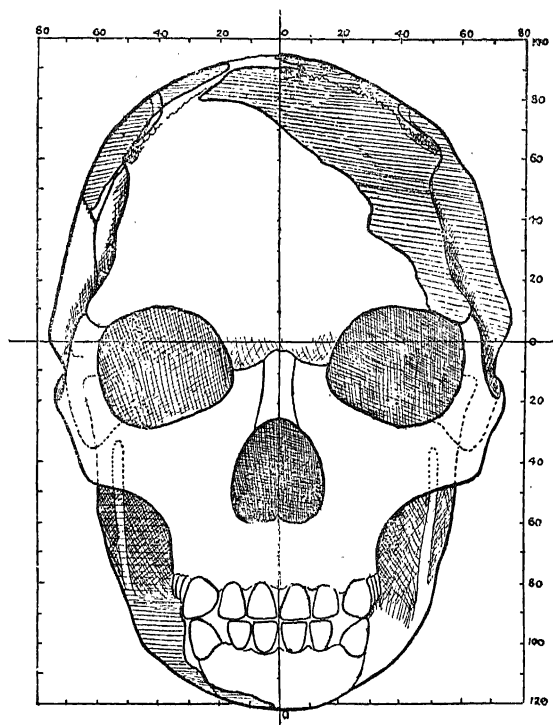
FIG. 185.—Face view of the skull of Eoanthropus as reconstructed by Sir A. Smith Woodward (half natural size). The parts shaded are those actually found.

the cranial cavity is so imperfectly filled that the sides lean inwards and gradually fade into a contracted crown or roof. In the modern skull, as seen from the front, the roof is usually dome-shaped. The forehead of Eoanthropus gives the impression of being contracted and ape-like ; its lateral borders, formed by the lines for attachment of the temporal muscle, approximate as they ascend. In anthropoids these lines may actually meet on

the vertex of the skull and form a median crest.   In the
modern human forehead the temporal lines become wider
apart, and the brow broadens towards the crown or dome
of the head (fig. 176).   In Eoanthropus, then, we see an
ill-filled head with sides which slope inwards.   In a
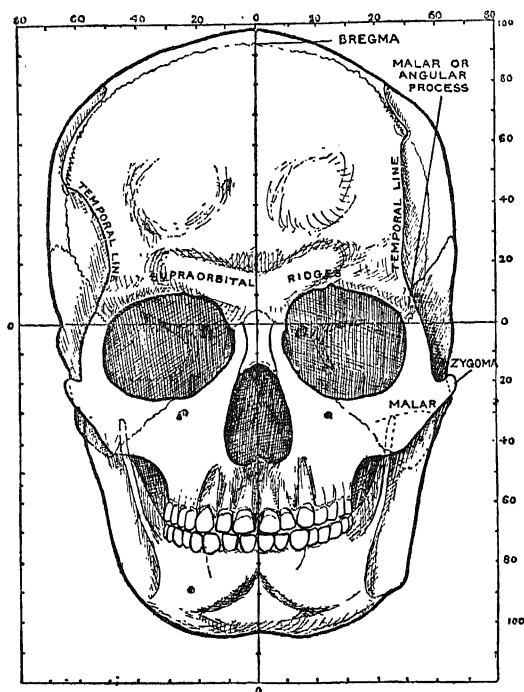
FIG. 186.—Face view of a modern human skull for comparison with
fig. 185 (half natural size).

general sense we may construe such characters as simian
in nature.

To complete this cursory review of the skull of
Eoanthropus as it originally left the hands of its recon-
structor, I add two further figures.   In fig. 187 the modern
skull is viewed from above ; in fig. 188 the same view is
reproduced of the skull of Eoanthropus.   In the modern
skull the arrangement of bones is simple.   The frontal
bone, forming the forehead, is joined behind to the

right and left parietal bones at the coronal suture. At the posterior end of the vertical view only the upper part of the occipital bone is seen; it becomes joined to the parietal bones at the lambdoid suture (fig. 187). Along the middle line, between the right and left parietals, passes the sagittal suture. At some distance to either
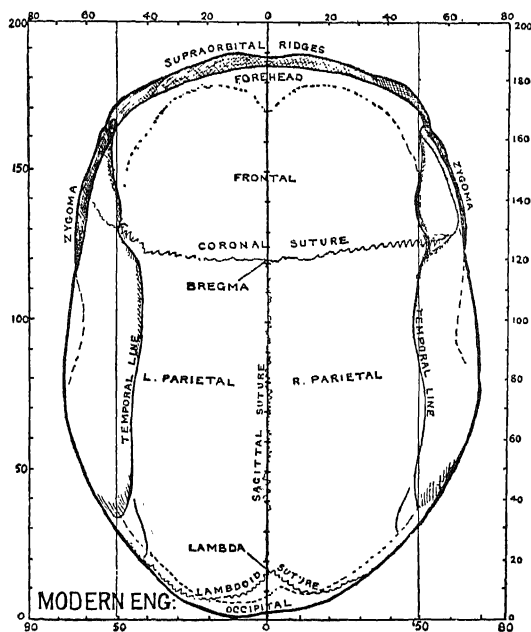
FIG. 187.—View of a modern skull from above, showing the bones and sutures of the vault (⅔ natural size). The plane of orientation is that used in fig. 184.

side of the sagittal suture is seen the upper limit of attachment of the temporal muscles—the temporal lines (fig. 187). Part of the bony scaffolding for the support of the face and jaws is seen on the forehead—the supra-orbital ridges. The cheek bars or zygomatic arches are just apparent; they pass on each side of the head in front of the ear, to end in the cheeks and thus strengthen and support the face. When we turn to the same view of the skull of Eoanthropus (fig. 188) we see representatives of the same parts, but their clear interpretation is

not an easy task because of the great deficiency in the forehead and along the whole length of the roof. The zygomatic arches, it will be observed, project far beyond the sides of the skull, as in anthropoid apes. There is no
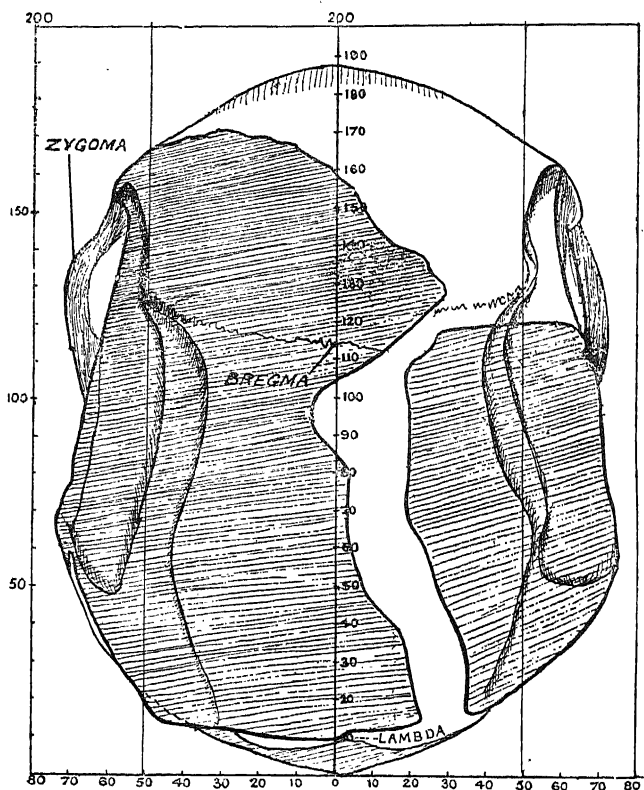
FIG. 188.—View of the skull of Eoanthropus from above, oriented on the plane shown in fig. 183. The parts shaded are those which were actually found (half natural size).

definitely moulded supra-orbital ridge shown; the fore-head is given a wedge shape. The temporal lines are clearly visible, both upper and lower. Only the upper of these lines are represented in the drawing of the normal skull (fig. 187). As regards general mass it is clear that the skull of Eoanthropus is the greater. It will

also be noted that there is a marked irregularity in its contour, and that there is a noticeable degree of asymmetry in its conformation, the right side being smaller and not quite of the same form as the left side.

When he had fitted the fragments of the skull into their approximate position, Sir A. Smith Woodward was able to obtain a cast of the cavity which held the brain. So closely does the brain fill the cranial cavity that such a cast reveals not only the size and form of the brain, but also many of the finer markings which give the anatomist a clue to the actual anatomy of the brain. The brain or endocranial cast was entrusted to Professor Elliot Smith for examination. His verdict, pronounced after his first examination, was that, " taking all its features into consideration, we must regard this as being the most primitive and most simian human brain so far recorded."

When we sum up all the characters which Sir A. Smith Woodward has portrayed in this new form of being—the anthropoid characters of the mouth, teeth, and face, the massive and ill-filled skull, the simian characters of the brain and its primitive and pre-human general appearance —one feels convinced that he was absolutely justified in creating a new genus of the family Hominidæ for its reception. This new genus he named *Eoanthropus*— dawn-man. Ever since Darwin impressed the truth of his theory of man's origin on his fellow-scientists we have expected to encounter man's progenitors, but no one, so far as I know, ever anticipated the discovery of one showing the remarkable mixture of simian and human characters—such a one as Mr Dawson brought to light at Piltdown.

In such a form was this representative of " dawning " humanity raised from his obscure bed at Piltdown and exposed to the merciless eyes of the scientific world. No sooner had he appeared than he became the subject of debate and the cause of hot contention. Some of his critics, we shall see, still wish to take him to pieces and give his skull to a man of the modern kind and his teeth and jaw to a chimpanzee. Nevertheless he has finally

emerged from his ordeal, chastened, perhaps, in many of the ape-like qualities originally attributed to him, as a real human being, but one in whom there still can be detected gross traces of man's simian ancestry. The being who could fashion the Piltdown bone implement was a long way in advance of " dawn-man " ; this title belongs of right to the man of Java—Pithecanthropus.

CHAPTER XXIX

THE DIFFICULTIES OF RECONSTRUCTION

In this chapter I propose to lead the reader into the rather intricate problem of skull reconstruction. So far as concerns the Piltdown fragments, I became involved in the puzzle of fitting them rightly together in the most casual manner. Indeed, from a reference to the published proceedings of the famous meeting on 18th December at which the discovery was announced, it is clear that I was then of opinion that any problem of reconstruction had been fully solved by Sir A. Smith Woodward. When the privilege of taking part in the discussion was extended to me, I gave it as my opinion that " the reconstruction of the skull had been executed with great skill "—only making the reservation that " in the reconstruction of the chin region of the mandible and the form of the incisor, canine, and premolar teeth, the characters of the chimpanzee had been too closely followed."

This opinion was based on a cursory examination of Sir A. Smith Woodward's reconstruction of the skull at the commencement of the meeting. In May of the following year (1913), anatomists were supplied with exact replicas in plaster of the various fragments, and also a copy of the original reconstruction—all of them the work of that excellent modeller, Mr F. O. Barlow. One day, soon after the arrival of the models at the museum of the Royal College of Surgeons, I sat down and depicted on the skull of an Australian native—one with a brain capacity of 1450 c.c.—the exact areas of the Piltdown

fragments, in order that visitors to the museum might have a ready means of ascertaining the actual parts of the skull which had been recovered. It will be remembered (see fig. 172, p. 515) that the greater part of the left parietal bone—which forms so large and important a part of the brain chamber—was recovered; I was surprised to find that the superficial area of the Piltdown parietal bone was only slightly smaller than that of the Australian native, the exact figures being 121·7 cm.² for Piltdown, 132·9 cm.² for the Australian. This surprise was increased when I came to compare the area of that part of the temporal bone—the squama or plate—which reaches up on the side of the skull and actually overlaps the lower bevelled ridge of the parietal (see fig. 184). It is true that part of the squamous plate was broken, but its original size can be estimated with some degree of exactitude. The Piltdown squama was larger than that of the Australian native; the area of the first named was 24·7 cm.², of the second, 21·4 cm.². Now, students of the human body have been in the habit of regarding a large temporal squama as indicating a large brain. It is true that a mere increase in thickness of the skull leads to an increase in the area of the squama, but even allowing for the thickness of the Piltdown skull, the plate was remarkably extensive for a brain of 1070 c.c. The size of the parietal bone and temporal squama indicated a capacity nearly equal to that of the Australian native. To find an explanation of these discrepancies—or characteristics, they might have proved to be—of the Piltdown race, I turned to Sir A. Smith Woodward's reconstruction to see if there was any apparent error in the manner in which the fragments had been fitted together. It was then I noticed a very marked degree of asymmetry in its formation; the right side was not only smaller than the left, but there was also a strange flattening of its hinder part.

We have always supposed that the skulls of primitive races are notably symmetrical; in the lower forms of man, as in anthropoid apes, the right and left halves

of the brain and of the skull are fairly exact copies of each other. Symmetry is a primitive mark; it is the most highly evolved—the most specialised—forms of human brains and heads which manifest asymmetrical conditions. A deformity of one or both sides of the head may be due to disease in life, or to earth-pressure after death, but no suggestion has ever been made that the asymmetry of the Piltdown skull was due to either of these causes. It was due, then, either to a high specialisation of the brain or to an error in reconstruction. In either case it was important to discover an explanation of those peculiar features which I have just mentioned, for when we come finally to assign any being to its scale in humanity, it is not the mandible, the face, the teeth, or limbs which guide us, but the master organ of the human body—the brain. We cannot tell the shape and size of the brain until the various skull bones which form the brain case are rightly fitted in position.

In fitting the parts of the skull together, we must begin at the hinder or occipital end of the head in this particular case, because the only fragment which reveals the middle line of the skull, and at the same time gives us a true indication of the width of the Piltdown head, belongs to the hinder aspect of the skull and forms part of the occipital bone. The aspect of the Piltdown head which we are trying to build up is exactly that seen in the person who sits in front of us in church or theatre. If the hair and soft covering parts were to become transparent we should see that the central part of the hinder wall of the skull is formed by the occipital bone (fig. 189). The lower or nuchal part of the bone is implanted in the neck, and gives attachment to those muscles which move the head. The nuchal part is shaded in fig. 189, so that it may be the more easily recognised. On either side of the occipital bone are placed the right and left temporal bones. In fact, the mastoid parts of these bones form lateral extensions of the area for the attachment of the neck. The mastoid processes are in reality levers by which the muscles of the

neck may balance and turn the head. A large part of the occipital—the supra-nuchal part—extends above the neck, under the scalp, until it reaches the right and left parietal bones. The suture or joint-line at which the parietal and occipital bones meet is known as the lambdoid suture (fig. 189). On each side of the hinder aspect of the
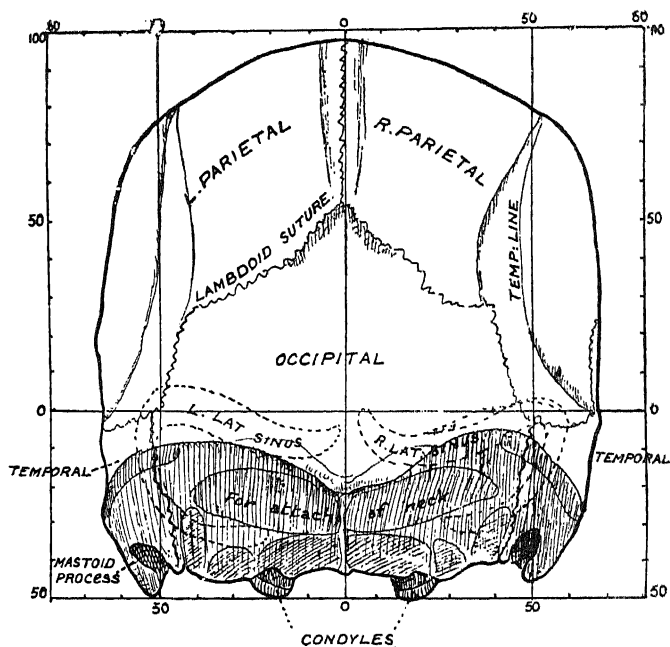
FIG. 189.—Showing the bones which form the hinder or occipital part of a modern skull (capacity, 1425 c.c.).

skull this suture is clearly seen to be made up of two parts —an upper, oblique, and a lower, almost vertical.

These are the parts which enter into the formation of the hinder part of the skull; before the Piltdown fragments can be rightly replaced one must bear such a picture in mind. It is also necessary to point out that the occipital bone is made up of right and left halves. In the nuchal region the ridge or elevation which indicates the middle line—the junction of the right and left halves—is very apparent; it lies between

the attachment of the muscles of the right and left sides of the neck, the sides of the neck being always of nearly equal size. In modern skulls, the right and left halves of the occipital, which lie above the neck, show a certain degree of dissimilarity or asymmetry. As a rule, the larger the brain and skull the greater the degree of asymmetry.

To bring out this feature of the occipital bone, I have been in the habit of representing the hinder view of the skull within such a framework of lines as is shown in fig. 189. It is within such a framework that we must build up and form our knowledge of this newly discovered extinct form of man. There are three vertical lines— the mid-line, and the right and left lateral lines drawn parallel to the mid-line at a distance of 2 inches (50 mm.) from it. The two lateral lines which form the sides of the frame are 80 mm. from the mid-line. A skull wide enough to fill the space between these extreme lines would have a width of 160 mm. (7 inches), and would be a very wide skull. Another line is important—the horizontal or zero line, which crosses the hinder and lower angles of both the right and left parietal bones. Above that line lies the chamber for the cerebrum—the organ of man's higher faculties ; below it the chamber for the cerebellum. Along or just below this line, on the inner aspect of the occipital bone and in the marginal space between the cerebrum above and cerebellum below, lie the great lateral blood-sinuses (fig. 189). The right sinus is usually a continuation of another great blood-sinus which passes along the roof of the skull, under the mid-line. Of the other two horizontal lines which bound the framework for the skull, one is placed 50 mm. (2 inches) below the chief or zero line, the other 100 mm. above it. A skull which reaches both the upper and the lower horizontal lines has a height of 150 mm. (5·8 inches)—this being rather more than is usual in the skulls of Englishmen.

When the outline of the occipital aspect of a modern skull is set in such a frame, it will be found that the

left half of the occipital bone extends farther outwards than the right half. In fig. 189 this normal asymmetry is exemplified. The vertical part of the left lambdoid suture passes out beyond the left lateral line; on the right side it falls short of that line. The left half of the occipital bone is the larger, because the corresponding part of the brain is the larger. The left hemisphere of the brain controls the right half of the body; hence it is believed that the preponderance of the left occipital pole of the brain is connected with right-handedness.[1] The occipital asymmetry is due to a specialisation of the right and left hemispheres of the brain. There is the most indubitable evidence that the left occipital region of the Piltdown brain was larger than the right; the impress of the cerebral lobes on the inner aspect of the occipital fragment leaves no doubt on this matter.

The reader may naturally resent the introduction of so many technical details. I can only plead that the method employed is of the utmost importance; it must be exact and logical if we are to obtain abiding results. It is into such a framework as has just been sketched that the Piltdown fragments must be fitted; at every turn we shall be checked by our guiding lines. One other matter, however, must be mentioned. It is clear that the hinder aspect of the skull will alter as we raise or lower the front end of the skull. It is therefore necessary to fix the front part of a skull which is to be examined or reconstructed at a level corresponding to our hinder line. This hinder line crosses the lower angles of the parietal bones and marks the downward limits of the occipital lobes of the cerebrum. The ideal level for the anterior end is one which corresponds with the lower limits of the frontal lobes.[2] If the anterior part of the base of the skull is preserved, this is an easy matter, but in the majority of fossil skulls the anterior part of the base

[1] See Professor Elliot Smith, *Anat. Anz.*, 1907, vol. xxx. p. 574.
[2] For further details of the subcerebral plane, see pp. 528, 589. For original description see article by the author, *Journ. of Anat. and Physiol.*, 1910, vol. xliv. p. 251.

is not preserved. As a rule, however, the lowest point of the eyebrow ridge—to be more exact, the junction of this ridge with the malar or cheek bone—is sufficiently near the plane we want to mark, namely, the level of the lowest part of the frontal lobe, so far as human skulls are concerned.[1] Having thus sketched the method to be employed, we are in a position to undertake the reconstruction of the Piltdown skull.

When we place Sir A. Smith Woodward's original reconstruction of the Piltdown skull within the framework just described, we are at once in a position to see how far this very ancient type of man agrees or differs in head form from modern man. In fig. 190 the parts of the skull actually recovered are shaded ; the missing parts are left as blanks. The whole occipital bone was not found ; only the middle area of the lower or nuchal division, with the ridge which marks the middle line of the neck and skull, and a considerable part of the upper or supra-nuchal part. A fragment (marked O′ in fig. 190, A) carries the supra-nuchal part of the occipital on the right as far as the lambdoid suture, where it comes almost in contact with the right parietal. We have, in this fragment, a sure indication, not only of the width of the upper part of the occipital bone, but also of the position and direction of the lambdoid suture. The right lambdoid suture, it will be observed (fig. 190, A), crosses the right lateral (50-mm.) line very obliquely ; it is not vertical, as we should expect from a comparison with a modern skull (fig. 189). A remnant of the left half of the lambdoid suture is preserved on the hinder margin of the left parietal bone (fig. 190). It ought to be, as far as direction is concerned, symmetrical with the corresponding part

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[1] The practical utility of this plane of orientation—the subcerebral plane—has been mentioned several times already. From a theoretical point of view it is superior to the Frankfort plane (see p. 409). The latter represents a horizontal axis or plane of the face, and for any investigation of the facial part of the skull it is most useful. It has, however, no relationship to the chief part of the skull—the part which forms the brain cavity.

of the right, and also, in accordance with the law already stated, should be situated farther from the mid-line. Exactly the reverse is the condition actually present; the parts *a*, *b* and *a'*, *b'* (fig. 190) certainly correspond, but the one is lying obliquely and crossing the 50-mm. line, the other (the left) is nearly vertical, and inside in place of being outside that line. Further, the right half of the skull is considerably larger than the left. There is no possibility of making the right and left halves of the occipital bone even approximately symmetrical on these
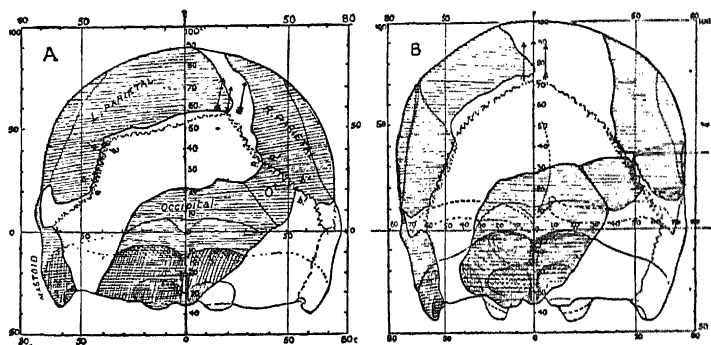
Fig. 190.—A. Drawing of the occipital aspect of the Piltdown skull as originally reconstructed by Sir A. Smith Woodward. B. The position assumed by the various parts when an approximate symmetry is restored. See also fig. 172, p. 515.

reconstructional lines. It may be thought that a marked degree of asymmetry was an inherent character of this ancient man, but before we accept such a conclusion it is necessary to remember that the more primitive the type of man, the greater the degree of correspondence in the right and left parts. We have also to keep in mind that the extreme degree of asymmetry may be due to malposition of parts.

On looking round for an explanation of the peculiar arrangement given by Sir A. Smith Woodward to the Piltdown fragments, I observed that he had placed the middle line of the roof along the fragment marked " left parietal " in fig. 190, A. If such were the true middle line, then there ought to be some evidence of the suture

between the right and left parietal bones, which meet along the mid-line. But of this suture there is not a trace. On fig. 190, A, I have placed three arrows, the middle one crossing the hinder angle of the left parietal bone. An examination of the original fragment leaves me in no doubt that the middle line lies at the point marked by the middle arrow, but, as will be seen subsequently, Professor Elliot Smith has formed a different opinion. Leaving the full proof that my identification of the middle line is correct to another chapter, let us try, as in fig. 190, B, the effect of placing the fragments so that the middle arrow falls into a median position. The extreme asymmetry of the lambdoid suture disappears. This is a presumptive proof that the parts have been placed in their right position. It is only when the point chosen in fig. 190, B, is placed in the middle line that an approximate symmetry is obtained.

When the upper angle at the hinder end of the parietal is replaced in its proper position the change in the skull is revolutionary. The height of the brain chamber is increased by nearly half an inch. The width and fullness of the top parts are enlarged. The brain capacity is augmented; the shape of the brain itself is changed. The anomalous conformation of the occipital bone, the extreme asymmetry of the lambdoid suture, almost disappear, and all the points we are familiar with in human skulls—no one has ever denied the humanity of the fragments—leap to the eye. The right and left halves of the lambdoid suture become not only symmetrical, but the left half, as should be the case because of the preponderance of the left hemisphere of the Piltdown brain, oversteps the 50-mm. line to a greater degree than it does on the right side. We have here the most ample confirmation that the lines on which we are proceeding must be right, for by taking them as our guides most of the anomalies of the original reconstruction disappear.

There were two points in this preliminary part of my investigation which gave me a great deal of trouble.

One relates to the two parietal bones. Both bones are rather mutilated—particularly the right. We have to determine what parts are missing from each bone. It will be seen that this question must be answered before we can proceed to the final adjustment of the two parietal bones on the sides of the head; the corresponding points must occupy the same positions on the right and left
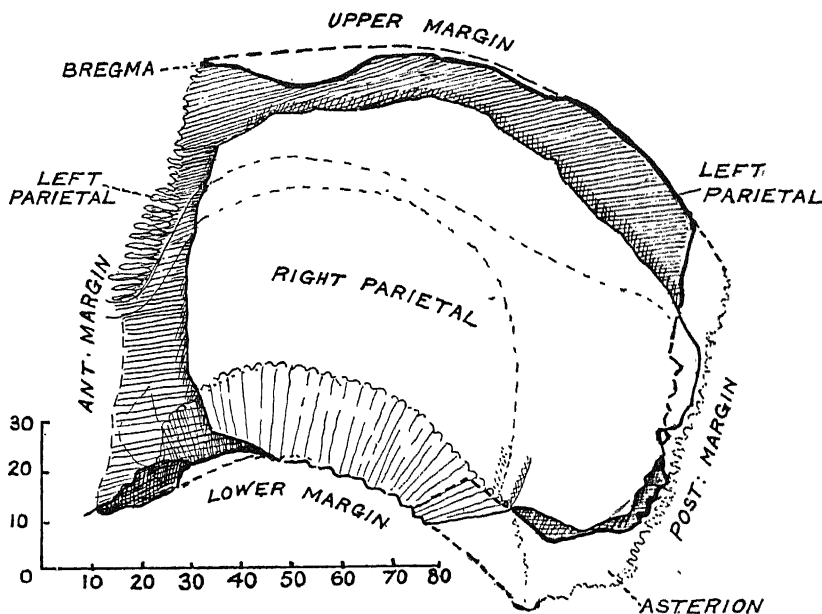
FIG. 191.—The right and left parietal bones superimposed to show how much of each is missing.

sides. The answer to this problem is given in fig. 191, where a " mirror " drawing of the right parietal is superimposed on corresponding parts of the right bone. On each side the lower border is preserved—the margin of which is bevelled for articulation with the plate or squama of the temporal bone. The most remarkable fact is that almost the same amount is missing from the hinder and lower border of each side. Fortunately, we can tell exactly how much is missing on the left side, because we possess the temporal bone of that side. When the

temporal is articulated with the lower border of the left parietal we see at once how much is missing at the hinder angle. When the left parietal was intact (see fig. 172, p. 515) its hinder angle came into contact with the adjacent parts of the temporal. Along the hinder margins of the two parietals remnants of the sutural lines are preserved. On both sides a trace of the middle part of the lambdoid suture can be detected—the preserved part on the right side rising upwards and projecting rather farther back than on the left side. On both sides the lower part of the lambdoid margin is missing for an extent of 12 mm. (about half an inch). On the left side, although the parietal reaches up to the middle line, a long marginal fragment, at least 10 mm. wide, has been broken away from the hinder border. On the right side the upper or roofing part of the parietal is altogether absent, the missing part at the hinder end being about 55 mm. in width. Having ascertained these facts, we are now in a position to adjust the hinder margins of the parietal bones on the right and left sides of the head. It is apparent that they must be adjusted so that the lower border of each bone is on the same level, and occupy the same relative position on each side. The distance of the hinder border of each parietal bone from the mid-line is indicated by the width of the occipital bone, which has been already determined.

Having thus settled the corresponding points in the right and left parietal bones, I now turn to the second point—small and seemingly unimportant, but one which gave me much trouble at first. It relates to the little fragment of the occipital which Sir A. Smith Woodward found (fig. 190, O′). Our conception of the head and brain form of this ancient human type turns on being certain that this fragment is rightly placed. A close inspection of the original occipital bone raises the suspicion that the fragment has not been rightly adjusted. When one scrutinises the fine vascular grooves and markings on the inner aspect of the fragment, and traces them to the crack where the union has been made to the main piece,

the fine vascular grooves and markings cease and are not caught up and continued beyond the join, which they should be if the fit were a true and accurate one. My suspicion that the union was not quite right arose, however, from two other observations. On the hinder margin of the right parietal is still to be seen a triangular notch (fig. 174, p. 517), marking the point where evidently the workman's pick pierced the skull. On the adjacent marking of the occipital fragment there is also a graze of the pick. That this graze is the opposite side of the same unfortunate blow there can be no doubt, for when the occipital fragment is brought opposite to the margin of the parietal, so as to complete the perforation made by the pick, it is clear from the agreement in thickness and in texture of the parts brought into contact that we have found a true relationship. Indeed we can surmise from the nature of the perforation wrought by the workman's pick that the skull was embedded in the gravel so as to expose its right hinder aspect to the blow.

By the same blow the hinder part of the right parietal was broken into two fragments—the splintering line starting from the point at which the pick perforated (fig. 190, B). I found, further, when the occipital and parietal bones were articulated as in the original model that the lower border of the right parietal always became half an inch too high. Detaching the occipital fragment, and giving it what was apparently its true articulation with the adjacent margin of the parietal, I also found that all the parts, previously out of place, slid into position. As I had suspected, there is a fragment missing at the line of junction, the true relationship of the fragment being that given in fig. 174. The failure to recognise the true position of the occipital fragment has given rise to some of the difficulties of those who have tried to discover the true nature of the Piltdown skull.

I have probably wearied my readers with the details concerning the reconstruction of the hinder aspect of the Piltdown head. It is not the skull itself which is the aim of our search; it is rather the brain which lay within

it—the organ with which this early representative of mankind measured and registered the world in which he lived. To know the brain we must rightly reconstruct the brain case. We are already in a position to form a rough estimate of its size. When the Piltdown skull, as reconstructed in fig. 174, is compared with that of a modern man (fig. 189) it is seen that the head of the ancient man is the more massive. In the modern sample, represented in fig. 189, the greatest width of the skull is 134 mm.; in the Piltdown skull this measurement is a little under 150 mm.; in the original reconstruction the greatest width is also 150 mm. If we deduct 10 mm. from this amount on account of the great thickness of the bony walls, the width measurement of the Piltdown skull is still 140 mm.—6 mm. more than in the modern skull represented in fig. 189. As regards the height of the cerebral chamber—the height of the roof of the skull above the horizontal or subcerebral plane — there is not much difference between the ancient and modern example, if we allow for the greater thickness of the Piltdown skull. The roof of the skull in our example of modern man falls short of the 100-mm. line; the roof of the Piltdown should just reach that line. If the length of the skulls were approximately equal, it is clear that the ancient brain should be the larger. The Piltdown brain was, as regards bulk, about the average for modern races. We need not be surprised to find that he was an artificer of some skill.

The reader may very properly offer the criticism that the conclusion as regards the width and size of the Piltdown skull turns on that small fragment of the occipital bone. He may well ask for confirmatory evidence. Substantiation of the conclusions reached can be obtained by a totally different method—one which carries us right into the principles of skull reconstruction If a cut is made across a skull so as to expose its walls in a vertical cross-section as in fig. 192, the composition of the bony wall enclosing the brain is seen to be simple. The base of the skull at this point is made up of three

bony elements—a bar of bone in the middle, a pyramid
of bone, the petrous part of the temporal, on each side
of it. The lateral walls and roof are formed by two
enclosing bones—the squama of the temporal and the
parietal bone on either side. Now, as may be seen from
fig. 192, the brain cavity of anthropoid apes and of men
is enclosed by corresponding bones, but in the ape the
parietal bones and the plate of the temporal are small
in size. As regards the size of the bones in the base of
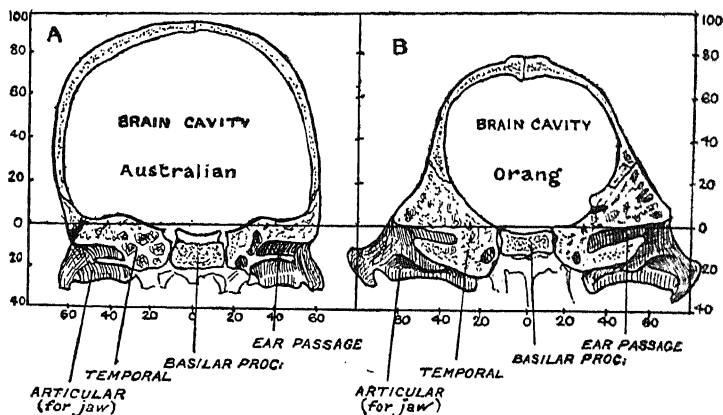
Fig. 192.—A. Transverse vertical section of the skull of an Australian
    aboriginal, to show the bones forming the base, sides, and roof of
    the brain cavity. B. Of an orang, to show the bones forming the
    base, sides, and roof of the brain cavity.

the skull, man and ape are very much alike. In the ape
the basilar process, and especially the petrous bones, are
large. The petrous bones, which contain the organ of
hearing, are of great size in anthropoid apes, because
they have also to afford a joint for massive jaws and
attachment for the huge muscles of the neck.

Two important points should be noted in the human
skull. The brain has so increased in mass that the
petrous pyramids of the temporal bones have been
forced into a horizontal position. The opening of the
ear passage lies below the level of the brain in the
human skull. In the anthropoid the petrous bone is
set obliquely; the ear-hole is situated at a higher level

as regards the floor of the brain cavity. The other point which is important for our present purpose is that the petrous bone reaches within a definite distance of the middle line of the base of the skull; it affords us a means of estimating the width of a skull. Now we have the left temporal bone of the Piltdown skull—almost the whole of the petrous portion and a great part of the side plate or squama.

In fig. 193 the composition of the Piltdown skull in transverse section is shown. I have supposed that the
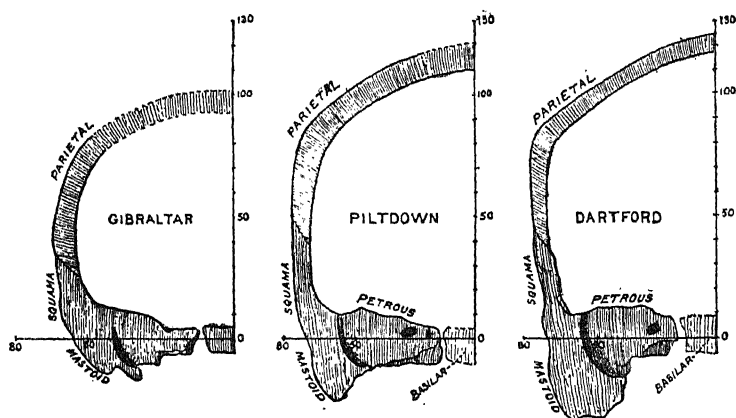
Fig. 193.—Reconstruction of the left half of the Piltdown skull compared with a similar section of the Gibraltar and of the Dartford skull.

basilar process is of rather more than average width—26 mm. In such a skull, with great massive bones, this bar was probably considerably above the dimensions seen in modern skulls. From the dimensions of the petrous part of the temporal bone we infer that the width of the Piltdown skull was at least equal to that of either of the two skulls shown for comparison in fig. 193—about 150 mm. We have thus an assurance that the indications given us by the occipital bone concerning the width and size of the Piltdown skull are well founded. The massiveness of the petrous bone, and its degree of obliquity as regards the transverse axis of the base of the skull, are primitive or simian marks (fig. 192); yet in this respect

the Piltdown skull is less simian than the Gibraltar skull (fig. 193).

A study of the occipital aspect of the Piltdown skull brings before us another feature in which it resembles those of the modern type. When viewed from behind, the heads of men of the modern type give the impression of being compressed from side to side (fig. 189). In
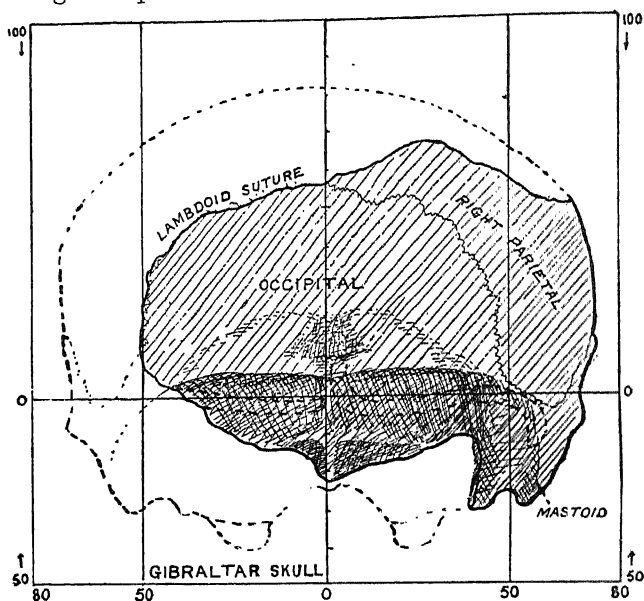
FIG. 194.—Occipital aspect of the Gibraltar skull, to show the manner in which Neanderthal skulls appear to be compressed from above downwards.

that extinct species of man—*Homo neanderthalensis*—the head was compressed in an exactly opposite direction, and the same is true of Rhodesian man (see fig. 145, p. 410), from above downwards. All known members of the race have their heads shaped thus. In fig. 194 is given an occipital view of the Gibraltar skull—the smallest of all the Neanderthal skulls yet discovered, the size of the brain cast being approximately 1150 c.c. Whereas the Piltdown skull almost fills the square in which it is placed (fig. 174), the Gibraltar skull falls far short as

regards height. In its width the Gibraltar skull is only 5 or 6 mm. less than the Piltdown, but as regards height it is 18 mm. less. In this feature of the skull—*platycephaly* it is called—the Neanderthal species resembled anthropoid apes. Two drawings of the occipital aspect of a young gorilla and of a juvenile chimpanzee will serve to illustrate this point (fig. 195). The skull of the chimpanzee is more platycephalic that that of the gorilla. In shape of head the Piltdown race resembled modern races of mankind.

The drawings of the occipital aspect of anthropoid skulls bring out certain other instructive characters. In the gorilla and chimpanzee the lambdoid suture—the line of junction between the occipital and parietal bones —is almost symmetrical as regards the two sides. In the Gibraltar skull we see the same kind of asymmetry in this suture as in modern races, and as in the Piltdown skull—an asymmetry due to the greater extent of the left half of the occipital bone. At the present time we attribute that preponderance to the larger size of the left occipital lobe of the brain, and indirectly to right-handedness. At the beginning of the Pleistocene period—probably much earlier—specialisation already had appeared as a distinguishing feature of the human brain.

Piltdown man had not only the flat-sided head form of modern man, but he also held and balanced his head much as we carry ours. This we believe was not the primitive method. Adult anthropoids are bull-necked— the head is deeply implanted in their strong, thick necks. In modern man, as in Piltdown man, the head is balanced on the neck ; there is a sharp demarcation at the junction of the neck with the head. In newly born anthropoids the neck is slender and the head relatively large. As the ape passes into childhood the neck grows in thickness, while the head—as regards size of brain—remains almost stationary. As the neck grows, it encloses and spreads over the occipital region. How the occipital region changes in the growing anthropoid is illustrated in

fig. 146, p. 412. In Piltdown man, as in modern man, such changes were of a minor degree. In fig. 195, A, B, the area of neck-attachment is demarcated by shading. In the young gorilla the attachment has extended upwards until it has reached a little above the level of the lateral blood-sinuses. In the chimpanzee, an older animal, the neck has extended upwards nearly an inch above the sinuses. In the Gibraltar skull, as in all Neanderthal skulls, the condition is that seen in the young gorilla (see figs. 194 and 195), but in the Piltdown skull, as is usually the case in the skulls of living races, the attachment of
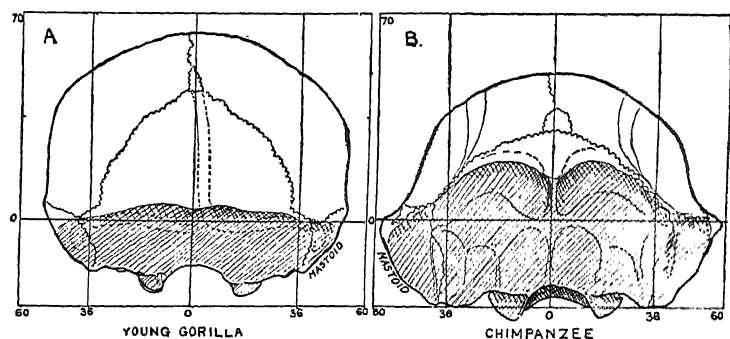
FIG. 195.—A. Hinder aspect of the skull of a young gorilla about three years old. B. The same aspect of the skull of a female chimpanzee about twelve years old.

the neck barely reaches the level of the lateral sinuses. Occasionally, however, the neck-attachment does spread above this level in living races, particularly in men of robust build, and such an extension also occurred in members of the Piltdown race. It will be remembered that Mr Dawson found in 1915 a fragment of a second occipital bone; in this the area of neck-attachment has spread 8 mm. above the level of the sinuses. It is particularly worthy of note that this second fragment[1] is so exactly alike in its markings to a modern bone, that its assignation to the Piltdown race depends entirely on the locality in which it was found and on the state of its fossilisation. In the manner in which the skull was hafted

[1] For description see *Quart. Journ. Geol. Soc.*, 1917, vol. lxxiii. p. 4.

to the neck Piltdown man corresponds with modern races and differs from the Neanderthal species and anthropoids.

One other remarkable feature is seen in the Piltdown skull, in connection with the fixation of the head to the neck. In the young chimpanzee the mastoid area of the temporal bone on each side is growing outwards into a thick, wing-like process to give an increased area for attachment of certain of the neck muscles (fig. 175, B). In the Gibraltar skull the same area forms merely a flattened knob—a condition which may be described as partially simian (fig. 194). In the Piltdown skull we see, as in modern races, and as in the Rhodesian skull, a pyramidal mastoid process projecting downwards behind the ear. It is a special adaptation to the balancing of the head on the neck. I have always regarded the wide attachment of the neck to the skull as a provision for enabling an animal to exert its bodily strength through its head and jaws. A full consideration of the lightly balanced head of the Piltdown man, with great jaws and apparently projecting canines, on the one hand, and of Neanderthal man, with his closely set head, strong jaws not furnished with fighting canines, on the other, renders this view no longer tenable. There seems to be no necessary correlation between projecting canines and firm fixation of the head.

After the discovery of the Rhodesian skull, Professors Elliot Smith and Hunter showed a new reconstruction which they had made of the Piltdown skull at a meeting of British anatomists (13th May 1922), in which the occipital region is modelled on Rhodesian lines. In Rhodesian man, as we have seen (fig. 139, p. 395), the area for attachment of the neck is extensive and is tilted in a backward as well as in a downward direction—an adaptation which gives room for the movement of the massive lower jaw. Now the lower jaw was equally big in the Piltdown race, hence in this new reconstruction the Piltdown occipital has been given a similar tilt and has also been placed higher on the occiput than in my reconstruction (fig. 132). They have opened out the

base of the skull farther than either Sir A. Smith Woodward or I dared to do, making the width between the outer surfaces of the mastoid processes, which represents the width of the neck, 152 mm. This is 8 mm. more than in the Rhodesian man, 14 mm. more than in the La Chapelle man, and almost as much as is found in adult male gorillas. To obtain such a width, they have placed the apices of the petrous bones 40 mm. apart, a width which, as may be seen from fig. 192, A, implies a basilar process of truly enormous size. And yet, as every anatomist admits, the occipital and temporal bones of this fossil skull are fashioned exactly as in modern skulls. As we shall see later, in this reconstruction Piltdown man is given a forehead of great width.

As on every public occasion, Professor Elliot Smith has justified Sir A. Smith Woodward's original reconstruction of the Piltdown skull, this new attempt to build up the cranial fragments in their true relationships is of particular interest. It was estimated from the original reconstruction that the brain volume was 1070 c.c.; Professor Elliot Smith's present estimate is " under 1300 c.c." " As a result (of this new reconstruction) the cranium falls into harmony with the chimpanzee-like jaw, and the paradox which had hitherto been a stumbling-block to the acceptance of the jaw as indubitably belonging to the fragments of the cranium now disappears." [1] To me the real paradox seems to be the possibility of fashioning a " chimpanzee-like " skull out of bones which are shaped exactly as in modern human skulls.

In this chapter I may seem to have entered into too many technical and uninteresting details. My justification is that we are dealing with the only document in our possession which throws light on human conditions at a long-past period of the earth's history—to a period which we have been in the habit of supposing as antecedent to the appearance of real man. Fossil fragments of human skulls are hieroglyphics which we must learn to decipher

[1] *Nature* (Report of Meeting of Anatomical Society), 3rd June 1922, p. 726.

by scientific methods. We have therefore to scan such documents with all the precision and critical acumen at our disposal if we are to lay our knowledge of early man on a sound basis. So far as we have gone, we see that, beyond any cavil, we are dealing with a human being with a head above average dimensions, and a brain very little, if any, below the amount allotted to the average European of to-day. Except for the thickness of his skull bones, the head was shaped and balanced as in us. Not only so, we see that asymmetry, which we believe to indicate a specialisation of the right hand, was already present. Further, we realise that, as regards shape of head, this early Pleistocene or Pliocene form of man was more like ourselves than was the Neanderthal type of man who survived to mid-Pleistocene times.

CHAPTER XXX

CAN FOSSIL FRAGMENTS YIELD RELIABLE EVIDENCE OF MAN'S EVOLUTIONARY HISTORY?

IF I were free to choose I would not inflict the reader with further dry and technical details concerning the Piltdown skull. The sharp controversy, however, which sprang up amongst anatomists in 1913, and which still continues abroad as well as at home, makes a plain and simple narrative impossible; we must take nothing for granted; every point has to be proved. The real issue is no longer the exact nature of Piltdown man: it is whether or not we can decipher man's evolutionary history from a study of fossil fragments. Under ordinary circumstances it ought to be a simple task for an anatomist to restore such a skull as that which has been hidden away a hundred thousand years or more in the Piltdown gravel; why, then, is there so much difficulty? There are two reasons. In the first place, the simian characters of the mandible indicate that the skull should be a small one—for the simian skull and brain cavity are small when contrasted with the human cranium. As to this matter, we have to remember that the law of correlation of the various parts of the animal body does not always hold true; the discoveries of recent years have shown that Nature in her time has built up animal forms in which characters culled from diverse animal types have been combined.

But there is another reason why we naturally suppose the brain of the Piltdown race to be a small one. We still live in the shadow of the time when man's first

appearance was regarded as one of the most recent events in the earth's history. I am not speaking of pre-Darwinian days, but of some forty years ago, when the theory of evolution was making headway, and when thinking people had accepted as a truth the origin of man from a more humble form. The contemporaries and successors of Darwin believed, and rightly believed, that they had made a great advance when they proved that men—such as you and I—lived with animals now extinct, animals like the mammoth, the woolly rhinoceros, and the cave-bear. The anatomists and geologists of forty years ago were very careful, almost penurious, when they drew a draft on the bank of Time ; they believed that their credit was strictly limited when they dealt at this bank. They were convinced that men of the modern type may have appeared towards the end of the Pleistocene period—some ten thousand years ago or more—when those extinct forms of mammals were living. They expected to discover, as they searched further into the past and reached the beginning of the Pleistocene and end of the Pliocene, a series of intermediate forms which would carry us rapidly towards a simian stage. Until a few years ago, many of our leading authorities believed that Pithecanthropus—a humanoid form, with a brain capacity of 850 c.c., little more than half that of modern man—represented our stage of evolution at the beginning of the Pleistocene period. The same men looked on Neanderthal species as representative of Pleistocene man, while modern races appeared just before the dawn of the recent period.

These two circumstances—a lower jaw with simian features and a belief in the recent evolution of the modern human brain—would naturally lead the discoverers of Eoanthropus to the conclusion that they had to deal with a primitive, small-brained form of man. We have just seen that Professor Elliot Smith, to suit the ape-like jaw, has given the Piltdown skull a chimpanzee-like shape. During these last thirty years, however, another line of evidence has been slowly accumulating, which seems to point to a much earlier date as marking the period of man's

evolution. Our estimate of the antiquity of the modern type of man must be sufficiently long to give time for the differentiation of this type into most diverse forms—African, European, Mongolian. It is more than thirty years since Sir Joseph Prestwich became convinced that the Kentish "eoliths" were of human workmanship, and were of Pliocene—not even late Pliocene—date. Fourteen years ago Mr Reid Moir discovered under the "Red Crag" of Suffolk—a Pliocene deposit—flints which are admitted by experts to be shaped by man's hand. Even Professor Sollas is now willing to believe that human beings were already in existence before Pliocene times.[1] In England and in Italy, as we have already seen, remains of men of the modern type have been found under circumstances which have led geologists to regard them as of early Pleistocene age.

All these discoveries of the modern type of man are disputed. It is therefore important to determine the size and form of brain in an early Pleistocene, or late Pliocene, type of man—one whose authenticity is beyond question. It will be seen, therefore, as I labour to make clear the nature of the Piltdown skull, that it is not the correct rendering of the details of the head form which is the real object I have in view; it is a much wider issue. We want to know what stage of brain development this particular type of man had reached so long ago. If the Piltdown man is a fair sample of his time, and if the opinions of Sir A. Smith Woodward and Professor Elliot Smith are well founded, then indeed we human beings have progressed rapidly to our present estate, and the great mask of civilisation which man has made a part of himself is in a geological sense merely a mushroom growth. If, on the other hand, we believe that in this early form of man we find a comparatively large, if somewhat simple, human brain, then our story is very different. Behind us must lie vast periods of human endeavour, reaching a much longer way into the geological past than most of us have hitherto suspected.

[1] *Ancient Hunters,* 3rd edition, 1924.

At this point I propose to give an account of an experiment, of which I was the willing subject, because it serves to bring out the difficulties of rightly interpreting and of reconstructing ancient skulls. The question is often asked: Are four fragments of a skull, such as those found at Piltdown, sufficient to give us a definite clue to the original form of skull? Apparently not; at least it was clear that reconstructions by Sir A. Smith Woodward and by myself indicated men of a totally
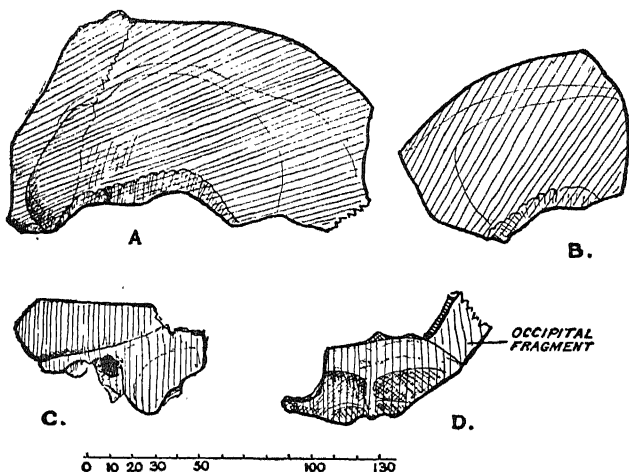
FIG. 196.—Fragments of test skull. A, Left parietal fragment; B, right parietal fragment; C, left temporal; D, occipital fragment.

different type. To test the matter, Professor F. G. Parsons of St Thomas's Hospital Medical School, London, made a proposal to me, namely, that he and some of his fellow-anatomists should select a skull, cut fragments from it corresponding to those found at Piltdown, and that I should attempt to reconstruct the entire skull from these fragments. I gladly accepted the proposal, and resolved, however the result should turn out, to make the experiment the subject of an address I had promised to the fellows of the Royal Anthropological Institute.[1]

[1] See *Journ. Roy. Anthrop. Instit.*, vol. xlix., July 1914.

On 16th January 1914, a fortnight before this lecture was due, the four pieces of a skull shown in fig. 196 came to me from Dr Douglas Derry of University College, London. They were representatives of the Piltdown fragments, and the task of reconstruction offered the same difficulties. Only on one piece—the occipital fragment—could any certain sign of the middle line of the skull be detected.

In fig. 196 is given the first step in the work of reconstruction. A drawing of the fragment of the right
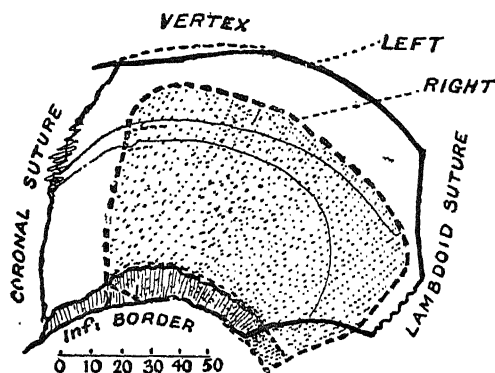
FIG. 197.—The right parietal fragment (stippled) of the test skull, superimposed on the left parietal, to bring out the corresponding points of the two sides.

parietal bone has been reversed and laid over one made from the left bone, so that corresponding points are superimposed. It is clear that when we attempt to build up the right and left sides of the skull, the parietal fragments must be so placed that the corresponding points of the right and left parietal bones match each other on the two sides of the skull. Our procedure is based on the fact that the skulls of all animals are built on a symmetrical plan—the right and left halves being alike, except in minor details. By a reference to fig. 191 it will be seen that the designers of this experiment had succeeded in reproducing a close parallel of the Piltdown problem.

The next step in the solution of the problem is shown in fig. 198. The left parietal fragment being the more complete is first built up, the missing parts being replaced by plasticine or modeller's wax. The left half of the skull is built up on a board, marked with measured lines, represented by those shown in fig. 198. The lines are really those which form the standard or conventional framework, employed in the illustrations of this book
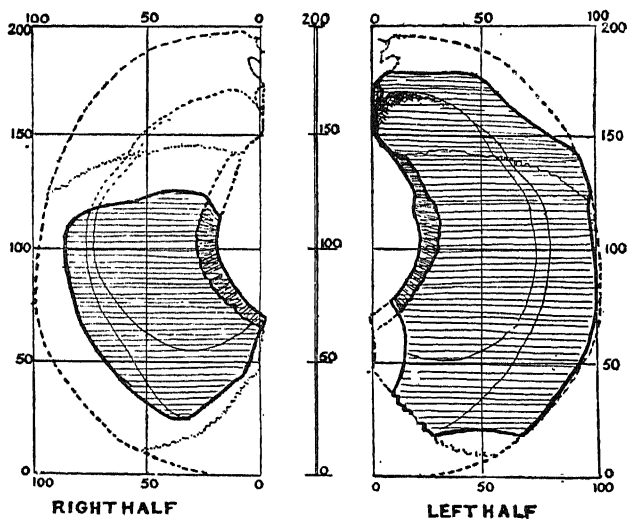
FIG. 198.—Showing the framework of lines on which the right and left halves of a skull are reconstructed from fragments.

when skulls are viewed in profile. When the left half is completed, the right half is then undertaken, as shown in fig. 198. The right half of the skull is built up on a similar framework of lines, the parietal fragment being placed so that it corresponds in all points with the parietal in the side already built up. If our reconstruction is right, then, when the right and left halves are brought together, to form the complete roof of a skull, all the corresponding points of the two sides should fall into corresponding positions. If the two sides are found to agree, we may presume that the points which were identified as marking the middle line of the skull along the roof, from forehead

to occiput, were approximately right. If the two sides are still discrepant, it is clear that we are wrong in our identification of the middle line of the skull, and we have to make other identifications and begin again.

Having thus built up that part of the roof of the skull which is formed by the two parietal bones, the halves are again separated and the next step taken is that shown in
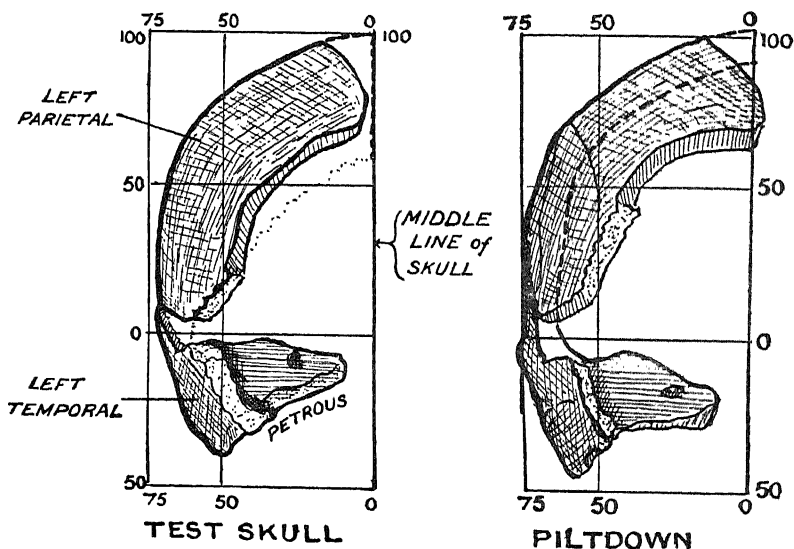
FIG. 199.—Showing the manner in which the left temporal bone is placed in position, and the left half of the skull built up (1) in the test skull, (2) in the Piltdown skull.

fig. 199. The left temporal bone is placed in position. There is not much difficulty in this part of our task. On the upper margin of the temporal there was preserved, exactly as in the fossil skull, a point at which the temporal and parietal bones made a true contact. Besides, even supposing such a point of contact were absent, we could not go far wrong, because there are so many markings on both the outer and inner aspects of the temporal and parietal bones to guide us to their correct apposition. When the temporal bone is applied we obtain the first real indication of what the original width of the skull

must have been. The temporal bone sends its petrous portion (fig. 199) inwards on the base of the skull. The apex of this petrous process reaches within 10 or 15 mm. of the middle line of the skull. In the majority of human and anthropoid skulls the distance of the apex from the mid-line is about 12 mm.; the allowance made in the reconstruction shown in fig. 199 is 13 mm.[1] The application of the temporal fragment at once shows if the former steps have been rightly made. If the parietal halves have been made too wide or too narrow, the apex of the petrous bone will be too far from, or too near to, the middle line along the base of the skull.

The identity of the problems presented by the test and Piltdown skulls is apparent in fig. 199. We note that in size and shape the fragments are not unlike. Certain minor points of difference are also to be recognised : (1) the parietal bones of the fossil skull are nearly twice as thick as those of the test skull—the first being 8 to 11 mm. thick, the latter from 4 to 6 mm.; (2) the Piltdown skull is actually the wider and the higher, but the extra width and height are due to the greater thickness of the bones. In the dimensions of the brain chamber they are nearly alike. A third point of difference must be noted. As in anthropoid skulls, the petrous part of the temporal bone descends as it approaches the middle line (see figs. 192 and 199), whereas in modern skulls this process is nearly horizontally placed so far as concerns its upper border. It is clear, however, that in shape of the bones and formation of the skull, Piltdown and modern man are framed on identical lines.

We now pass on to another stage of the reconstruction, illustrated by fig. 200. The first step consisted in shaping the right and left parietal regions ; the second in completing the left half of the cranium by applying the temporal bone, and, as I ought to have added in the previous paragraph, to the right half also—the missing right temporal bone being replaced by modelling a

[1] The allowance made by Professors Elliot Smith and Hunter must have been over 18 mm.

duplicate of the left temporal bone. In the third stage, the right and left halves of the skull are brought into apposition, leaving a wide, gaping space in the hinder wall to be filled by the occipital fragment. In fig. 200 the occipital fragment has been placed in position. If we have proceeded rightly in the two previous stages, then the occipital fragment ought to slip into place, without force or pressure, and take up a natural relationship with neighbouring parts of the skull. In the case of the test skull, an approximately correct result was obtained on

PILTDOWN RECONSTRUCTION   TEST RECONSTRUCTION
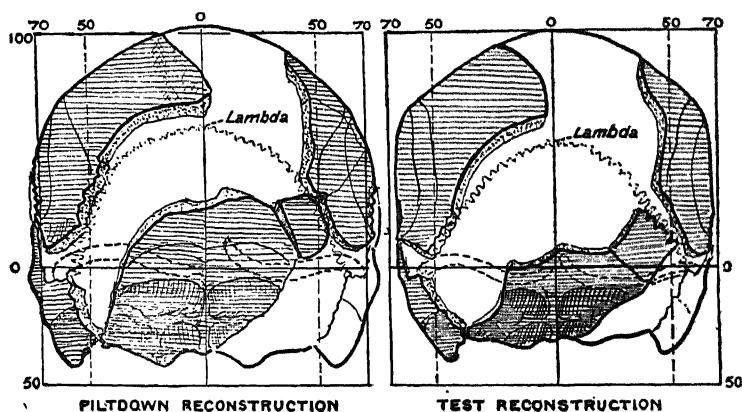
FIG. 200.—Reconstructions of the Piltdown and test skulls viewed from behind, to show the application and fit of the occipital fragments.

the third attempt; in the case of the Piltdown skull, where the problem is more complex, an approach to symmetry and a correct adjustment of parts came only after many experimental reconstructions.

How near a true reconstruction of the original form can be obtained by the use of such a method is apparent in fig. 201. As regards the width and height, the reconstruction was in close agreement with the original skull from which the fragments given to me had been cut. The general form was rightly reproduced. There were certain minor errors which could have been eliminated had there been sufficient time at my disposal. It is obvious in fig. 201 that the right parietal fragment is

placed too low, and that the occipital bone is too high. But as regards general outline and chief diameters the result of this experiment was reassuring.

The criticism may be made here that in Sir A. Smith Woodward's original reconstruction the right and left halves of the skull have the appearance of being symmetrical (fig. 202, A). The right half, however, is really the larger, and when we examine the details it is at once seen, as already pointed out, that the right and left halves of the lambdoid suture are altogether

RECONSTRUCTION.   CAST OF ORIGINAL.
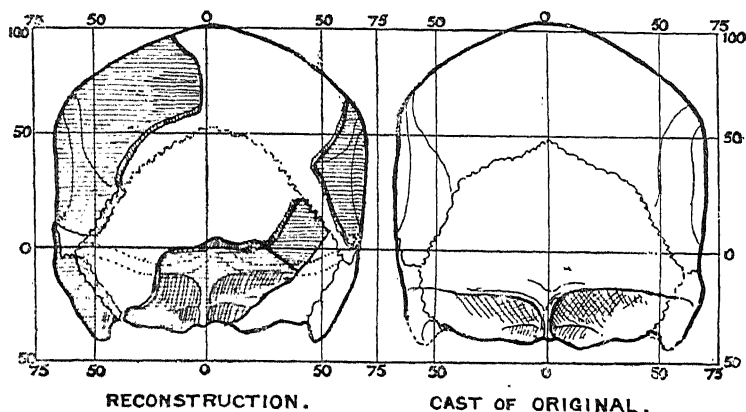
FIG. 201.—View of the reconstruction and of the original test skull.

unlike. No animal skull has ever been seen with such a degree of asymmetry of the two sides of the occipital bone. Professor Elliot Smith is of opinion [1] that a slight adjustment of the parietal fragments will remove those defects and leave the brain capacity much of the same size as represented in the original reconstruction. In fig. 202, B, another reconstruction of the Piltdown skull is produced. In this reconstruction the middle vertical line of the diagram cuts the hinder angle of the left parietal fragment at the point where Professor Elliot Smith believes he can detect definite signs of the suture between the right and left parietal bones. If

[1] See *Nature*, 1913, vol. xcii. p. 318. Also *Quart. Journ. Geol. Soc.*, 1914, vol. lxx. p. 95.

this is the position of the suture—for I can see no trace nor sign of it—then this point must be placed in the middle line of our reconstruction. The left parietal, in fig. 202, B, has been orientated on the middle line as determined by Professor Elliot Smith, and if the adjustment may be truthfully described as a slight one, its effect, as regards the size and shape of the skull, is revolutionary. Instead of being, as in the original model, a wide skull with a depressed crown — somewhat resembling the
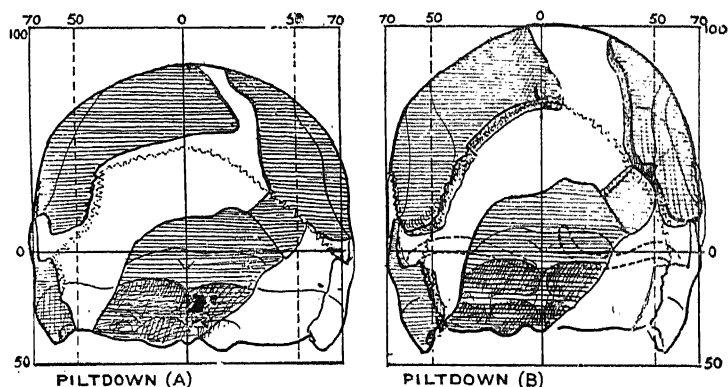
FIG. 202.—Occipital view of Sir A. Smith Woodward's original reconstruction of the Piltdown skull (A) contrasted with a reconstruction carried out according to the identifications of the middle line by Professor Elliot Smith.

Neanderthal form of crania—it becomes a narrow, high skull, exactly similar in outline and structural details to modern skulls. The " slight " adjustment has certainly removed many of the defects of the original model, as well as transformed the chief character of the skull, but an inspection of fig. 202, B, will show that there still remains a high degree of asymmetry which can be largely removed by placing the parts in the position shown in fig. 200. Whether the reconstruction shown in fig. 202, B, or in fig. 200, A, is accepted as the right one, there is one conclusion which cannot be avoided—the Piltdown skull in its occipital aspect is a counterpart of that of modern man.

In the preceding paragraphs the narrative has strayed in advance of the natural sequence of events. The actual reconstruction of the experimental skull occupied me the better part of two days. Having made exact drawings of it, according to the method used in this book, I handed the skull and drawings to Dr Derry at University College. He then showed me the cast of the original—the skull
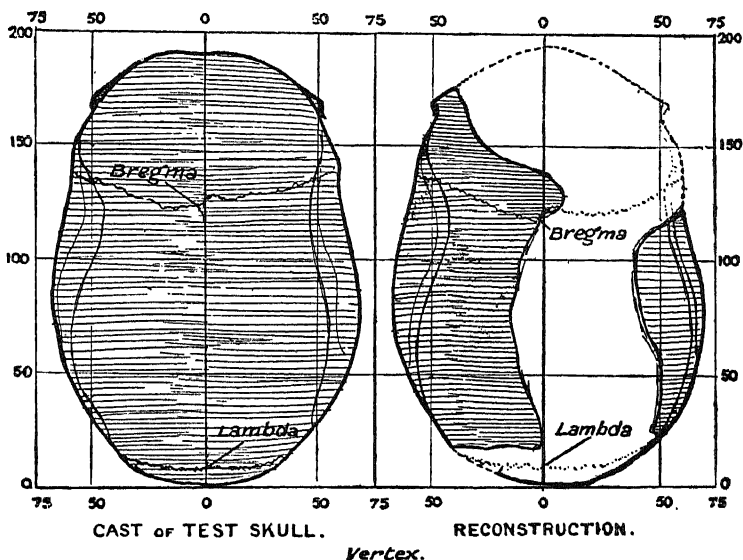
FIG. 203.—Drawing of the vault of the test skull, with a corresponding drawing of the reconstruction.

of an ancient Egyptian—a woman, with a peculiar form of head and a brain capacity of 1395 c.c. The estimate I returned of the brain capacity, namely, 1415 c.c., was not very wide of the truth, and as regards general form and actual dimensions I was relieved to find the method I had followed had given—except in one respect—a fairly accurate reproduction of the original.

How closely the problem of the experimental or test skull simulates the one presented by the Piltdown fragments becomes very apparent when we view the reconstructed skulls from above (fig. 204). In neither skull is

there any certain mark of the middle line along the vault. In the test skull, the sagittal suture of the vault was prematurely obliterated, and, as may be seen from fig. 203, only at one point—immediately in front of the bregma—was the middle line really represented. There were two guiding marks to help me : (1) on the under surface of the projecting frontal fragment—in front of the bregma (fig. 203)—an indication of the great blood-sinus which passes backwards under the middle line of the vault
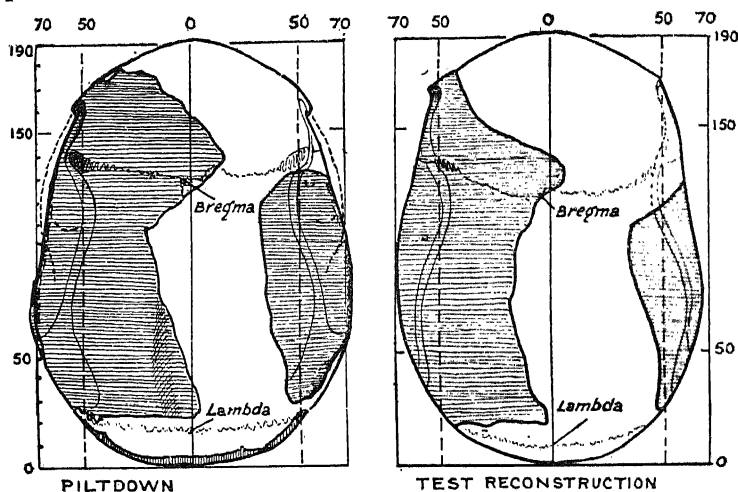
FIG. 204.—The author's reconstruction of the Piltdown and test skulls viewed from above.

could be detected ; (2) I surmised, as proved to be the case, that the sagittal suture, between the right and left parietal bones, turned a little to the left as it reached the bregma. It was only on such a supposition that I could account for a trace of an oblique suture on the hinder part of the frontal projection—apparently the commencement of the coronal suture of the right side. The position of the lambda (fig. 203) was also rightly placed. The vascular markings under the hinder angle of the parietal fragment, and the fact that the lambda is rarely placed more than 10 mm. in front of the occipital end of the skull—when orientated on the plane described in this

book—showed me that at least 15 mm. had been cut away from the hinder end of the left parietal bone (fig. 203).

As may be seen in fig. 204, the markings presented by the Piltdown skull, in the region of the bregma, are very similar to those of the test skull. The left coronal suture can be definitely traced to the broken edge behind the frontal projection. On the hinder margin of the frontal projection itself can be traced a short part of an oblique suture (fig. 204). It is not unusual in modern skulls, especially in large specimens showing a considerable degree of asymmetry in the conformation of the right and left halves, to find a forward inclination at the commencement of the right coronal suture (see fig. 207, B). In such cases, as in the test skull, but often to a greater degree, the anterior end of the sagittal suture diverges to the left of the middle line. On the under surface of the frontal projection of the Piltdown fragment we also find an indication of the middle line in the form of a ridge-like elevation. The corresponding aspect of the test skull is marked by a groove, as is usually the case in modern skulls. But a median elevation of the skull, fitting into a groove or depression between the right and left frontal lobes of the brain, is not a rare occurrence in even modern skulls.[1] In the reconstruction of the Piltdown skull, shown in fig. 204, the frontal fragment is so placed as to pass 15 mm. to the right of the middle line of the vault. At the hinder end of the reconstruction it will be seen that I have placed the lambda 15 mm. in front of the occiput. A piece, at least 15 mm. in extent, is missing from the hinder end of the left parietal bone just in front of the lambda. In so thick a skull it is probable that the lambda was situated as far forwards as is shown in fig. 204.

.The similarity of the Piltdown and Egyptian skulls, seen in the reconstructions represented in fig. 204, leaves

[1] The frontal fragment found by Mr Dawson shows, as I had here inferred, that the internal median crest reached a remarkable development in Piltdown man.

us in no doubt that in both cases the head was built on similar lines—at least as regards the part of the cranium containing the brain. In actual width the Piltdown is the greater, because of the thickness of the bones; the brain chamber in both is approximately of the same width. As we have already seen, Professor Elliot Smith's determination of the middle line of the vault is slightly different from that shown in the preceding illustrations.
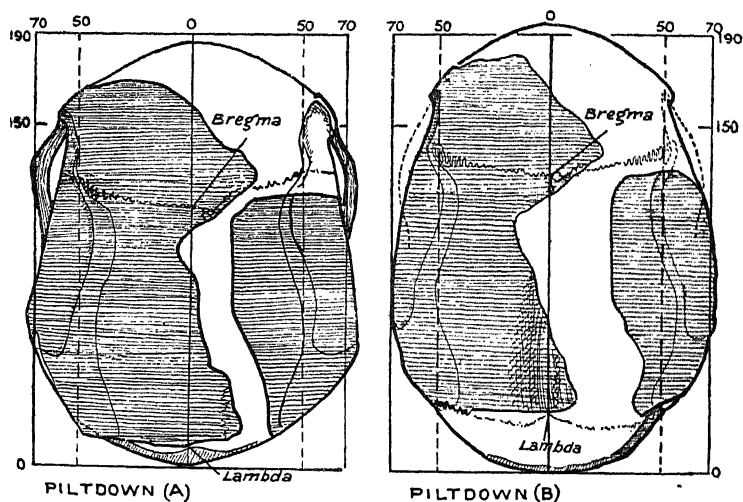
FIG. 205.—Drawing of the upper aspect of the Piltdown skull as reconstructed by Sir A. Smith Woodward (A), and a reconstruction based on the identification of the middle line by Professor Elliot Smith (B).

In fig. 205 are reproduced corresponding drawings made from the original reconstruction and a reconstruction made with the parts placed on the middle line of the vault as identified by Professor Elliot Smith. In the latter reconstruction (fig. 205, B) the middle line is only a few millimetres to the left of that represented in the Piltdown reconstruction shown in fig. 204. In each case the size and form of the skull as viewed from above are those we are familiar with in modern skulls. On the other hand, the upper aspect of the skull of Eoanthropus, as originally modelled, is altogether peculiar in its form. It is wide and short, the malar processes on each side of

the forehead appear projecting, almost as in apes, while the temporal lines converge towards the middle line, somewhat after the manner seen in the skulls of young anthropoids (fig. 206). With the correct apposition of parts all these irregular features disappear, and the characters seen in modern skulls take their place. Both Professor Elliot Smith and Sir A. Smith Woodward locate the lambda at the posterior extremity of the parietal fragment (fig. 205).

From an examination of the vault we can learn a great deal concerning the peculiar cranial characters of the Piltdown race. The condition of certain parts may be described as ultra-modern—a condition which we scarcely expected to meet with in a very ancient form of man. We can best realise the significance of such features by examining their degree of development in the cranial vault of an anthropoid ape—such as a female chimpanzee, the least brutal of the anthropoids in appearance (fig. 206). The forehead of the chimpanzee, just above the orbits, is crossed by a strong bar of bone—the supra-orbital ridge or torus. The projecting outer ends of the bar form the bony projections known in human anatomy as the external angular or malar processes, the ends of which can be felt very distinctly at the outer margins of our own foreheads. Two great bars of bone—the zygomatic arches—pass from the cheeks to the base of the skull in front of the ears. All these outlying parts of the skull form a bony scaffolding from which the muscles acting on the jaws gain an extensive origin. The brain case of the ape is small and does not provide space enough for the origin of the great muscles of mastication. Hence the outlying bony framework. As we have seen, the supra-orbital torus reached enormous proportions in Rhodesian man. It was the opposite in Piltdown man ; the median fragment of frontal bone found by Mr Dawson, shows that in him the supra-orbital ridges had a modern conformation and were in nowise pronounced.

Before leaving the chimpanzee's skull, two other points should be noted : (1) that the face is so projecting, so

thrown forwards or prognathous, that it is very apparent
in front of the supra-orbital ridge ; (2) buttresses or bony
flanges are thrown out around the hinder part of the skull
to increase the area for attachment of the muscles of the
neck.   In the chimpanzee, then, we see a primitive con-
dition, one in which the brain is small—it varies in size
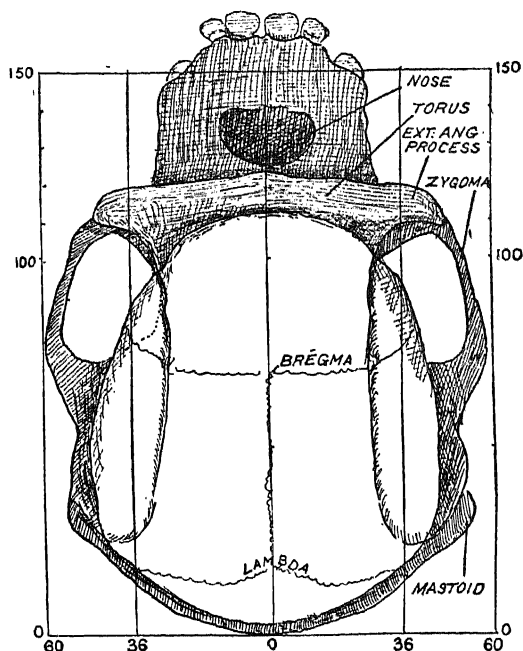
Fig. 206.—Skull of a young female chimpanzee viewed from above.   The
skull was set on the plane described on p. 581.

from 300 to 400 c.c., a fourth of the human size—and in
which bony scaffolding and processes are thrown out to
meet the needs of a brutal musculature.   The various
features just enumerated in the chimpanzee's skull are
also represented in that strange, mid-Pleistocene species
of humanity—Neanderthal man (fig. 207, A).   The great
supra-orbital bar is apparent—no development of this
kind has ever been seen in a modern human skull—ending
in strong and prominent external angular processes.   The

zygomatic arches projected outwards, coming clearly into view when the skull is looked at from above. The great increase in the length and width of the cranial cavity in Neanderthal skulls renders these brutal features much less apparent than in the chimpanzee. There is another simian feature in the shape of the Neanderthal cranial cavity. In Neanderthal man we have seen that the brain cavity was compressed from above downwards, as in anthropoid apes. It will also be noted, if one surveys
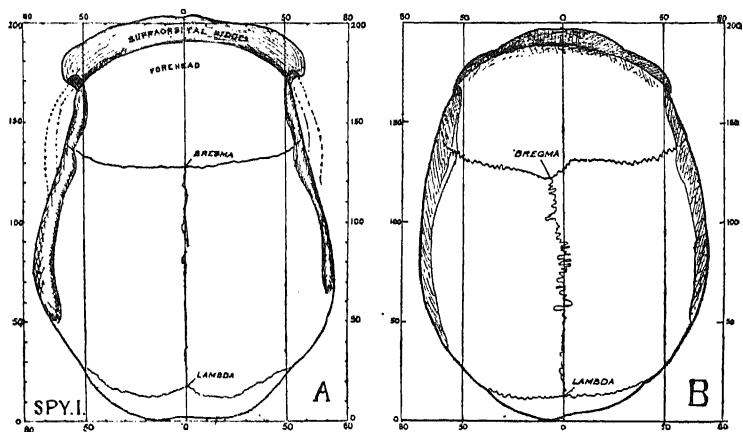
FIG. 207.—A. The vault of a Neanderthal skull, showing the simian form of eyebrow ridges. B. The vault of a modern skull, showing well-developed eyebrow ridges of the type usual in present-day races, and also an asymmetrical condition in the region of the bregma, as in the Piltdown skull.

the vault of the chimpanzee's skull from front to back, that the cranial cavity increases in width until almost the occipital region is reached; then it contracts abruptly. The same configuration may be noted in Neanderthal skulls. The significance of this feature is not known, but it is a simian character which is absent in the skulls of modern man and also in the Piltdown specimen. In this character Rhodesian man, as in so many other respects, occupies a position between the Neanderthal and modern types. In these skulls the greatest width is reached above the region of the ear, some distance in front of the occiput (compare A and B in fig. 207).

In modern skulls the supra-orbital ridges, external angular processes, and zygomatic arches have the form and dimensions shown in fig. 207, B. These processes are of a similar shape and size in ancient skulls of the modern type. The outer part, which ends in the external angular process, is demarcated more or less sharply from the elevations of the brow ridges situated over the root of the nose. The external angular process projects only 5 or 6 mm. beyond the contour of the forehead and brain case.

We now turn to the Piltdown skull (fig. 204). Only one part is preserved of the supra-orbital region, that is the external angular process of the left side. Although this process is thicker and stouter than in any modern skull I have ever seen, it is not projecting nor even prominent. Indeed, as will be seen when the skull is viewed from the front, it does not project more than 3 or 4 mm. beyond the lateral contour of the forehead (fig. 254, p. 693). That is exactly the opposite condition to what we expected to find in a very ancient representative of humanity. As regards this feature, the Piltdown skull is ultra-modern. It is just such a condition as we should expect to find correlated with a full-sized brain.

A view of the skull from above gives us an opportunity of forming an opinion on two of its chief dimensions— its length and width. In Sir A. Smith Woodward's reconstruction the maximum length is 190 mm.—approximately the same as in an average modern Englishman. In the same reconstruction the width is represented as 150 mm. —a wide skull, 8 or 10 mm. more than is usual amongst English people. Taking these measurements, 190 for length and 150 for width, we see that the width is 79 per cent. of the length. The Piltdown skull is thus on the verge of being classed amongst the round heads—the brachycephalic group of humanity, with a width proportion of 80 per cent. or more.

We have always expected to find long-headedness as a character of ancient man; it is so amongst most of the skulls of Pleistocene age, but not invariably so. In the

reconstruction of the Piltdown skull shown in fig. 204 the length is represented as 194 mm., slightly more than in Sir A. Smith Woodward's reconstruction. There is this difference, however : I have reduced the allowance for the forehead and increased the length of the occipital region (figs. 204 and 205). The maximum width is also the same—150 mm. The width is thus 78 per cent. of the length. In relative and absolute measurements of length and width my reconstruction differs very little from the original model. Thus, as exemplified in the specimen discovered, the Piltdown race tended towards round-headedness. In anthropoid apes the actual cranial cavity is of the round or short form. The real significance of round and long heads we do not know ; brachycephaly is found in anthropoid apes and in the most highly evolved of modern human races.

Before leaving the upper aspect of the Piltdown skull, there is one other feature which deserves mention. In figs. 206 and 207 the temporal lines are indicated ; they are arranged with approximate symmetry on each side of the skull. Now, the temporal ridges have an important bearing on the problem we have in hand. They will be observed to commence at the external angular processes of the frontal bone, and to sweep backwards on each side of the skull, crossing the coronal suture and ultimately terminating behind, above the ear. The lines limit, on each side of the skull, that area from which the temporal muscles take their origin—the chief muscles which act on the lower jaw. With a large jaw we expect to find a large and extended temporal muscle. If the muscles are large, then we should expect these lines to reach well upwards on the side of the skull, towards the middle line. Nature is economical in her use of material ; the bones of the skull have to enclose and form a brain chamber ; they have also to serve as a surface from which the muscles of mastication take their origin. If the brain cavity is small, as in the chimpanzee, then the muscles may occupy the whole lateral aspect of the skull, and the temporal lines may actually meet along the middle line

of the roof of the skull. As the brain cavity enlarges, a larger space becomes available than the temporal muscles need, and therefore the temporal lines are placed at a distance from the middle line. If the brain cavity becomes very large, these lines are widely separated from the middle line. What, then, is the condition in the Piltdown skull? In Sir A. Smith Woodward's reconstruction the temporal lines reach within 40 mm. of the middle line; in the modern English skull with a capacity of 1425 c.c., shown in fig. 187, p. 533, the lines reach within 50 mm. of the middle line. With a capacity of only 1070, as estimated by Sir A. Smith Woodward, and with such a long and projecting jaw as he found with the skull, we expect the temporal muscles to be large and the temporal lines to ascend farther on the sides of the skull than they actually do—if the skull were a small one. We have seen that the middle line cannot be as in the original reconstruction; when the parts are placed so that the sutures are symmetrical we find that the temporal lines are not 40 mm. but 52 mm. from the middle line. In the Dartford skull, with a capacity of 1750 c.c. and with a lower jaw which we may presume was not much larger than in us, the distance is only 70 mm. These facts are in harmony with the other evidence I have brought forward, all tending to show that we are dealing with a skull with a fairly large brain capacity.

In this chapter we have surveyed the Piltdown skull from two aspects—from behind and above. The result of this survey, and the comparison of the fragments of the skull with corresponding parts of modern skulls, convince students of anatomy that in general conformation, in actual dimensions, and in brain capacity the head of the Piltdown race was remarkably similar to that of modern races. We hope, also, that it has become evident to the reader that the reconstruction of human skulls from fossil fragments is not a matter of guess-work but is a procedure based on the laws of craniology.

HEADS—ANCIENT AND MODERN—IN PROFILE

SOME sixteen years ago the late Colonel Willoughby Verner brought me, from a cave in Spain, some fragments of a human skeleton. They were still thickly encrusted by the stalagmite which covered the floor of the cave, and when struck they resounded exactly as if they had been made of porcelain. They were petrified—true fossils. Colonel Verner discovered the cave; it had never been explored before—at least in modern times. On the walls were crude hieroglyphs. Nothing was then found to give a clue to the date at which the cave had been inhabited or when the human remains came to be deposited there, but recent inquiries make it probable that the bones he brought to me were of Azilian date (see p. 79). Among the few fragments were the upper ends of both right and left thigh bones of a small person, probably under 5 feet (1500 mm.) in height, truly human in shape, but with peculiar features which were new to me. It was therefore important to find out more about this individual—to discover the characters of the head— but all that was available for this purpose were the left temporal bone, the hinder half of the left parietal bone, and a fragment of the right. My attempt to reconstruct the skull from these fragments taught me a great deal. I saw that it would be possible to reconstruct the whole skull from such fragments with some approach to accuracy, but before such a task could be carried out a new method of studying skulls must be first elaborated, and then applied. The same problem confronted me when I

obtained the cranial fragment found near Bury St Edmunds. It came to be a matter of great importance to know what kind of person this Bury St Edmunds fragment belonged to, for it is the only human fragment so far found in England which can be assigned to the age of Acheulean culture.

When I began my investigations one point became very evident; the method usually employed in measuring and recording modern skulls and heads was useless. In the routine examination of skulls we place them so that the ear-hole and the lower margin of the orbit are on a level, on the same plane—the Frankfort plane. In ancient skulls the lower part of the orbit is nearly always broken away; often the temporal bone, with the necessary ear passage, is missing. As a rule little more than the vault of fossil skulls is found; therefore in the vault we must find the base line from which we are to reconstruct the whole skull. Now on the vault there are two very definite points which, at first sight, would seem to serve our purpose. At the front end, on the lower brink of the forehead, just over the root of the nose, is the projection or point known as the glabella (fig. 208). At the hinder end, just where the vault slopes down to join the neck, is a well-marked projection—the inion or external occipital protuberance (fig. 208, o). A line drawn from the glabella in front to the inion behind would seem to provide us with the kind of base line we need for the reconstruction of the missing parts of the skull. These points were used by the late Professor Schwalbe, and are still employed by many anatomists, but I could not accept them because I knew them to be—at least in certain skulls—movable and variable in position as regards the brain. The points needed for a base line must be fixed, at least as regards their relationship to the brain. In young anthropoid apes both glabella and inion are low down near the base of the skull. The vault of the skull rises high above a base line joining those two points. As the young ape begins to mature, the muscles of mastication grow in size, the neck increases in thickness,

with the result that the glabella and inion ascend towards the vault of the skull (fig. 208). Hence in the adult the vault of the skull appears to be much lower than in the young. If we were to use the inio-glabellar base line we should infer that the brain of the adult was much smaller than that of the young. The same change occurs, but in a less degree, in human skulls. Hence we
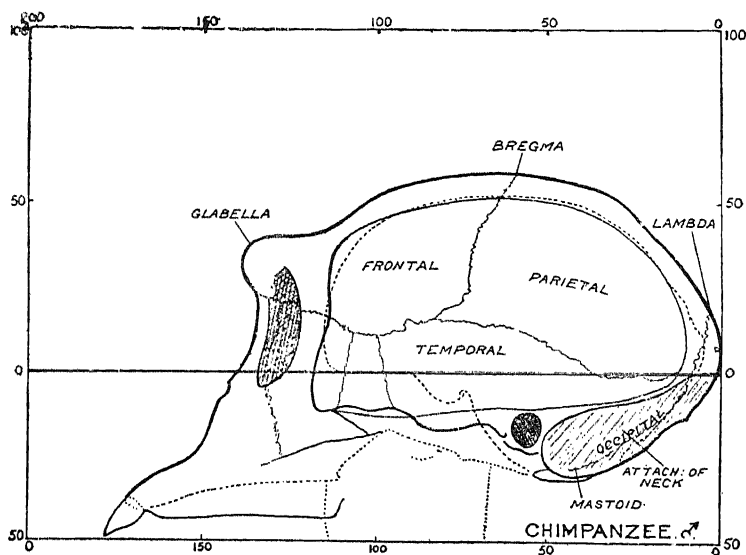
FIG. 208.—Profile of the skull of a chimpanzee to show the plane of orientation. The outline of the brain chamber is stippled.

must look for a more fixed base than that supplied by the inion and glabella.

Ultimately the base line which I selected was one which roughly corresponds with the lower margin of the cerebrum or brain proper. It is plain that the secrets we wish to wring from such fragments of skulls as may come to light are the size and form of brain they enclosed. Our methods should therefore be framed with these objects in view. Now the hinder lower angle of the parietal bone has a constant relationship to the brain, and is nearly always preserved in fossil skulls. To this angle is attached the horizontal partition which separates

the cerebrum above from the cerebellum below, not only in man, but in all animals allied to man. The posterior inferior angle of the parietal—the " asterion " as the point is named—is one which will serve well the purposes of a standard or base line for the hinder end of the skull. At the front end of the skull, as has been mentioned on p. 580, it is more difficult to get such a point as we want. The point needed should correspond with the lower limit of the frontal lobe of the cerebrum. If the base of the front part of the skull is preserved in the region of the presphenoid, then we have the level or plane which will serve our purpose. A line drawn along the skull from the level of the presphenoid to the asterion would give us just such a base line as we need, for between that base line and the vault of the skull lies almost the whole of the cerebrum. The anterior part of the base, however, is usually broken away or decayed, and we have to fall back on some other point. The one which seems to me most suitable is the external angular process of the frontal, or, to be more precise, the junction of this process with the malar bone (fig. 209). The base line, then, on which we propose to orientate a cranium for examination is one which begins anteriorly at or near the fronto-malar junction [1] and passes across the hinder lower angle of the parietal behind (fig. 213).

Seeing we are to place so much reliance on the external angular process and its junction with the malar bone, we must look closely at its relation to the brain. In fig. 209, B, the position which this process holds to the brain is shown in a modern English skull. The angular process, marked by two **, is 5 mm. ($\frac{1}{5}$ inch) above the level of that part of the base of the skull on which the frontal lobes of the brain rest. Numerous observations on modern human skulls have shown that the outer end of the process—the fronto-malar junction—fluctuates a

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[1] In practice, I take the mid-point of the fronto-malar suture—a point midway between its anterior or orbital end and its posterior or temporal end. For an indication at the hinder end of the skull, I take the mid-point of the suture between the mastoid process and parietal bone.

little above or a little below the level of the brain; but for the purpose we have in view it is a reliable enough guide and gives us approximately the anterior brain level. This rule holds good, not only for skulls of the modern type, but also for those ancient ones of the Neanderthal type. Strong and massive as the angular process is in the Gibraltar skull, its outer end is a fairly accurate index to the level of the basal parts of the frontal lobes
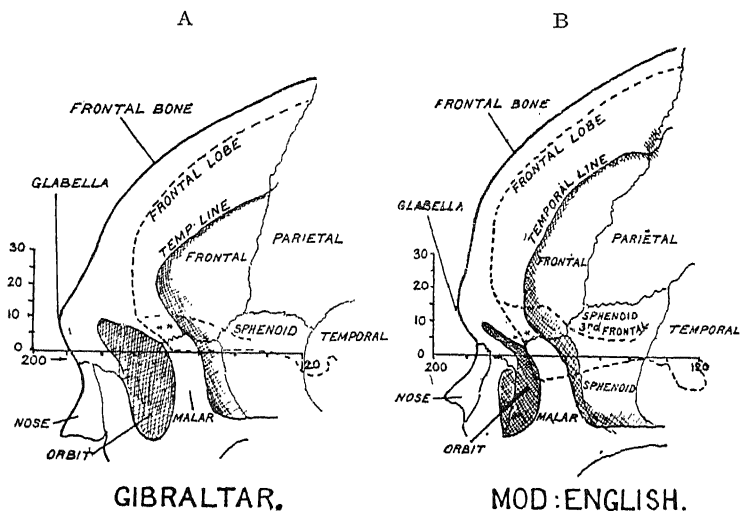
Fig. 209.—A. The relation of the external angular or malar process to the level of the base of the frontal lobes of the brain in the Gibraltar (Neanderthal) skull. B. The same relation in a modern English skull.

(fig. 209, A).   When, however, we examine the condition in anthropoid apes we find a different relationship (figs. 208 and 210, A).   The outer end of the process lies 20 mm. ($\frac{4}{5}$ inch) above the base of the frontal lobes. If we draw our base line at the fronto-malar level, we should greatly underestimate the brain capacity of an anthropoid skull.   An anthropoid condition is one we must be prepared to meet in a primitive human skull, such as the Piltdown, especially when we keep in mind the simian characters of the lower jaw.   So far as concerns the skull itself, we have met only with the characters of a

true human skull, inclining decidedly towards the modern
type.   We expect, then, that the angular process of the
frontal will be about on a level with the base of the
frontal lobe.   But we must make certain of this relation.
Now, there is a reliable method of telling whether
the external angular process is situated as in anthropoids
or as in man.   If the reader will examine the figure of
the modern English skull (fig. 209, B), he will see the
various bones which form the side of the skull behind
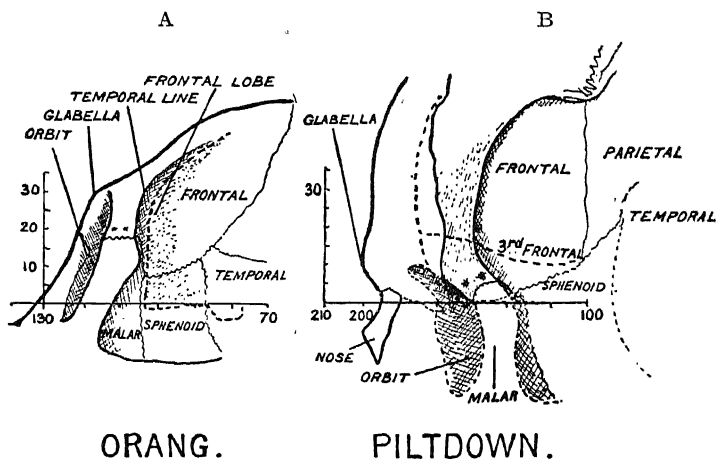
FIG. 210.—The fronto-malar region in the skull of an orang
and in the Piltdown specimen.

the angular process—the area which is covered by the
temporal muscle and is known as the temporal fossa.
In this area the coronal suture descends between the
frontal and parietal bones until it ends in a transverse
line or suture which separates the sphenoid—the part of
that bone known as the " great wing "—from the frontal
and parietal bones.   It will be further noted that the
suture between the angular process and malar is con-
tinued backwards between frontal bone and malar.   In
modern English skulls the trend of the fronto-malar suture
is usually in a backward and upward direction.   In the
anthropoid skull, however, the fronto-malar suture usually

descends almost vertically (see fig. 210, A). The vertical position of this suture tells us at once that the angular process is in the high or anthropoid position, and therefore lies some distance above brain level. A very slight degree of the anthropoid condition is present in the Gibraltar skull (fig. 209, A) and to a considerable degree in Pithecanthropus (fig. 150). What is the condition in the Piltdown skull ? There can be no doubt about this point ; the sutures necessary for a solution of the question are present (fig. 210). The fronto-malar suture, shorter than ever seen in a human skull hitherto, is truly horizontal in direction. As viewed in the actual specimen, its trend is backwards with a tendency to ascend. We may be certain, then, that when we select the external angular process of the frontal as marking the lowest level of the frontal lobes we are using a base line which will give us reliable results.[1]

We have evidence from another source which tells us we are proceeding on a safe basis. The external angular process holds a definite relationship to an important part of the frontal lobe, that part known as the third or inferior frontal convolution, which is generally regarded as being connected with the acquisition and use of speech. The third frontal convolution lies directly behind the angular process ; in many heads a distinct elevation or " bump " marks the position of this important area of the brain. The inferior frontal convolution is situated at a higher level than the more deeply placed parts of the frontal lobe. In a modern skull this convolution lies $\frac{1}{2}$ an inch above the base line (see fig. 209, B, where the lower margin of the third frontal convolution is indicated by a stippled line). In the Piltdown skull

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[1] It is particularly worthy of note that in the skull of the infant gorilla the fronto-malar suture has the same relation to the brain as in human skulls. Herein we see another instance of characters which are present only in fœtal or infantile stages of anthropoids becoming retained throughout life by man. The rise in level of the fronto-malar sutures in apes is part of the ascent of the eyebrow ridges which takes place during the eruption of the teeth.

that part of the roof of the eye-socket on which the third frontal convolution rests is preserved ; we therefore know the level of this convolution in the Piltdown skull (fig. 210, B). If we allow for the greater thickness of the skull bones, the relationship of the inferior convolution of the frontal lobe to the external angular process is almost the same in the Piltdown skull as in modern man (figs. 209, 210). In the fronto-malar region the characters of the Piltdown skull are not simian ; indeed, as will be shown in the next paragraph, they are rather ultra-modern.

The temporal line — a line or ridge marking the anterior limit or space from which the temporal muscle takes its origin—descends on the angular process (fig. 209). As we have already shown, this process itself must be regarded as part of the bony scaffolding thrown out as a basis for the apparatus of mastication. Now the relationship of the temporal lines to the frontal lobe of the brain is a matter worth our attention. When the anthropoid skull is examined in true profile it will be seen (figs. 208 and 210, A) that the temporal line is situated in front of the anterior limit or frontal pole of the brain. In the Gibraltar skull this line descends behind the frontal pole, but only 8 mm. ($\frac{1}{3}$ inch) behind it (fig. 209). In modern English skulls this is also the case, but the temporal line is still further back, from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch (fig. 209). Now in the Piltdown skull—even supposing the forehead is curtailed and made vertical— the temporal lines are at least 15 mm. ($\frac{3}{5}$ inch) behind the frontal poles. The relation of the temporal lines to the frontal poles of the brain is thus the opposite of simian ; the line is farther back than in the average modern skull. Indeed, a glance at the various figures just given (figs. 209 and 210) will show that the frontal part of the temporal lines in the Piltdown skull is more vertical than any hitherto seen in a human or anthropoid skull. In all human skulls, ancient and modern, the external angular process bends backwards and downwards as it joins the malar or cheek bone. In the Piltdown skull the terminal

backward bend is almost absent; it ends abruptly, pointing outwards.

I know that I am trying the patience of my readers when I labour these points. My excuse is that this fragmentary skull is the only document from which—at the present time—we can learn anything of a race of mankind which is removed from us by a period which
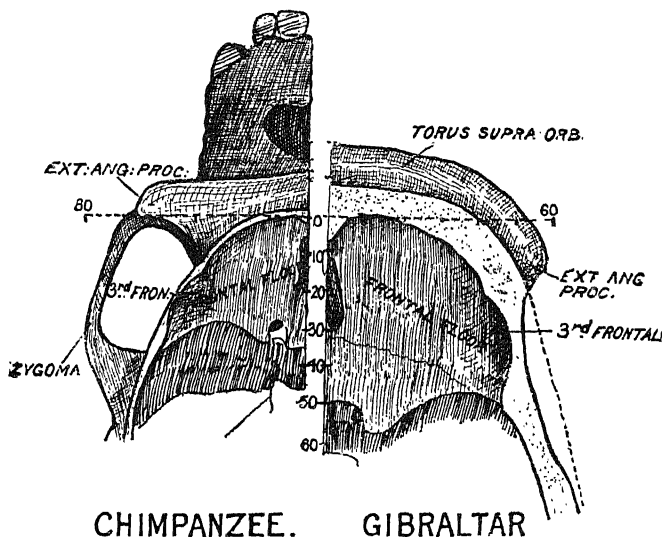
FIG. 211.—Section across the anterior end of the left side of a chimpanzee's skull and the right side of the Gibraltar skull, to show the relation of the external angular process to the third frontal convolution.

has seen a series of at least six thousand generations of mankind come and go. We have to see how far our methods of interpretation can give us a glimpse of the mental status of man at such a remote period. We are making some headway, and it is clear that a region of the skull which lies so close to the brain centres of speech is one which we must explore to the full. I propose, therefore, we should view this region, not only as seen with the head in profile, but also from above. In fig. 211 a horizontal section has exposed the anterior part of the floor of the skull of a chimpanzee, that part on which

the left frontal lobe rests. The impress of the third or inferior frontal convolution is seen. Far in front of the fossa or impress for this convolution is seen the external angular process of the frontal. On the right-hand side of the figure is shown a corresponding section of the Gibraltar skull. The external angular process is in front of the third frontal convolution. If one could conceive a great increase in the bulk of the frontal lobes of the chimpanzee's brain it is easy to see how the condition in
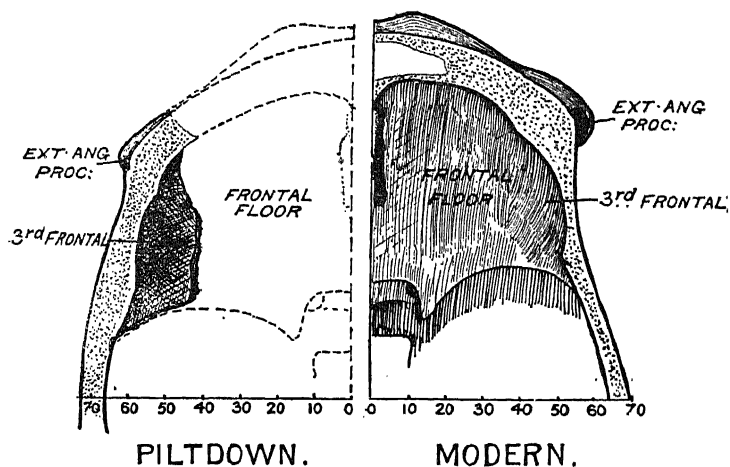
PILTDOWN.   MODERN.

Fig. 212.—Horizontal section of the left frontal bone of the Piltdown skull, and of the right frontal region of a modern skull, to show the relationship of the external angular process to the third frontal convolution.

the Gibraltar skull might be evolved from a simian arrangement. In fig. 212 the condition of parts in the Piltdown skull is contrasted with that of a modern specimen. The external angular process is less prominent in the Piltdown skull ; it is also situated rather farther back, more directly over the third frontal convolution than in the modern skull. It is clear that as regards this relationship the Piltdown skull is the opposite of simian. As regards the development and relationships of the external angular process, modern man is rather more simian than Piltdown man.

Having thus established a base line from which we can

work, we are now in a position to reconstruct and interpret the lateral aspect of the Piltdown skull. We shall see what this ancient man looked like when his head was viewed in profile—the most instructive of all views to a student of anthropology. The points needed for a base line—the external angular process and posterior inferior angle of the parietal bone—are preserved and can be defined with precision. It was also on this base line that the experimental reconstruction, described in the previous chapter, was carried out. That experiment throws a clear light on the nature and dimensions of the Piltdown skull, but it is necessary for us to return to it once more.
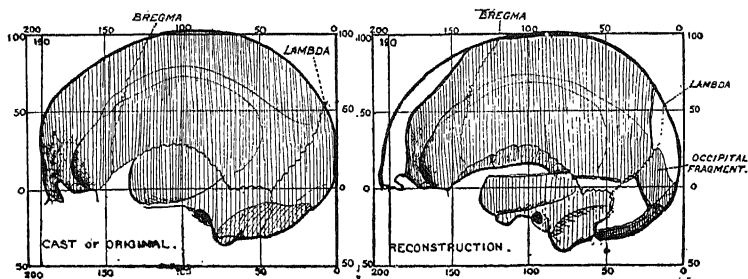
FIG. 213.—Profile of the test skull and of the reconstructed skull, orientated on the lines described in the text.

In fig. 213 are shown drawings of the original Egyptian skull and of the reconstruction as seen from the side. The reconstruction reproduces the height of the original with exactitude ; in both, the vault rises just above the upper limit of the frame, and is thus a little more than 100 mm. (102 mm.) above the base line. . The upper margin of the ear-hole is 15 mm. below the base line, and therefore the height of the vault above the ear-hole is 117 mm., a very common measurement in the skulls of modern Englishmen. Turning now to fig. 214, where the test reconstruction is compared with the Piltdown skull, the reader will be impressed with the degree of resemblance which they show. In the ancient skull the vault rises to the same height ; the ear-hole is at the same level. The auricular height of the Piltdown skull is 117 mm., a

millimetre or two above the mean for modern Englishmen. But a deduction has to be made ; the vault of the fossil skull is so thick that we must reduce the height by about 5 mm. to obtain a comparable measurement. In the Gibraltar skull the auricular height of the vault is 98 mm., with no allowance made for the thickness of the vault. In the latter skull the vault rises 88 mm. above the base line, while in the Rhodesian skull it rises to 95 mm. ; in Pithecanthropus the vault was very low, only 74 mm. above the base line (fig. 216). The importance of the auricular height as an index of brain size is very apparent ;
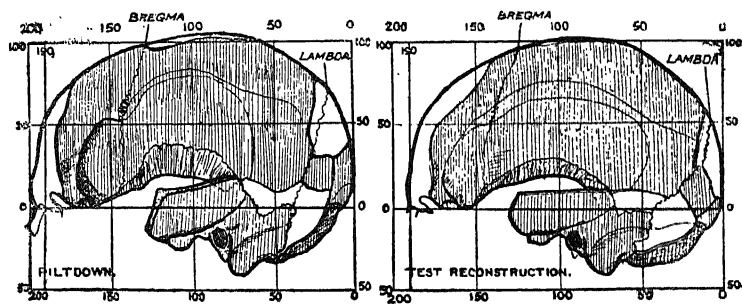
FIG. 214.—Profile of the reconstruction of the test skull compared with the reconstruction of the Piltdown skull.

the more the brain expands, the larger it becomes, the more is the vault of the skull lifted above the base line. As regards height of vault, the Piltdown skull is in agreement with skulls of the modern type.

Every well-planned experiment is instructive, and in this respect the one which my colleagues designed for me formed no exception. It will be seen from fig. 213 that my attempt to restore the forehead was a complete failure. In the original skull the upper part of the forehead is prominent, while the lower part, above the root of the nose, recedes, thus falling short of the conventional anterior limit—the 190-mm. line. The reconstruction shows exactly the opposite conditions, the total length of the skull being nearly 5 mm. more than it should have been. I made an unpardonable blunder in

two respects. In the first place, I had concluded from the rather large size of the mastoid process—placed just behind the ear—that the fragments I had to put together were parts of a man's skull, and therefore gave the reconstructed skull the prominent eyebrow ridges of the male. If I had looked carefully, I should have seen that the area for the attachment of the neck in the skull I had to reconstruct (fig. 213) was small—a characteristic female mark, for the neck of a woman is more slender than that of a man. The contour of the boss on the frontal bone, too, should have wakened a suspicion of a forehead which was drawn inwards, not prominent, in the region of the eyebrows.

This error again drew my attention to the reconstruction of the Piltdown forehead. All along I had been alive to the fact that we had no means of drawing any accurate conclusion as to the shape of forehead from so small a part as that represented in the original discovery of the Piltdown skull, but I supposed, with a set of teeth and a mandible so well developed as those which belong to Eoanthropus, that the eyebrow ridges must have been prominent. It will be seen from fig. 214 that I had carried the forehead almost to the 200-mm. line in my first reconstruction, giving the skull a total length of 200 mm. I am now convinced of this being too much. In every form of reconstruction of the skull of Eoanthropus one feature is always in evidence—the height and prominence of the upper part of the frontal bone. The curve given by the contour of the profile in front of the bregma (figs. 214, 215) suggests not a low and receding forehead as in Neanderthal man, but a high forehead, prominent in its upper part, and rather retracted than projecting as it merges in the eyebrow region. Hence, in revising my attempts to obtain the true form of the head of Eoanthropus in the light of my experiment in skull reconstruction, I remodelled the eyebrow region, making the maximum length of the skull 194 mm. (fig. 215). This inference proved to be right ; Piltdown man had a steep upright forehead. In the beginning of 1915, as we

have seen (p. 502), Mr Dawson found a fragment which gives us the contour of the central part of the forehead. It was found two miles distant from the original site of discovery and it is therefore most improbable that this fragment can be part of the original skull, although it has the same thick spongy texture and is in the same state of fossilisation. The area of the part found is shown in fig. 251, p. 690, and it will be seen to reach the middle line of the forehead. We can thus obtain, from its inner border, a vertical section of the forehead. Such a section is shown in fig. 216, A, where it is superimposed on a
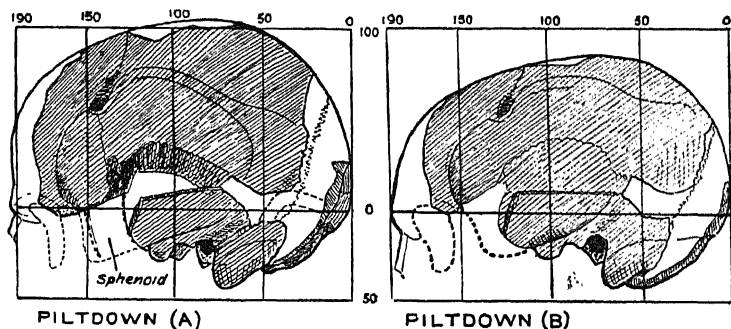
FIG. 215.—Two reconstructions of the Piltdown skull. A, By the Author ; B, from the model by Sir A. Smith Woodward.

corresponding section of the frontal bone of an Australian aborigine, a male. In its upper part the Piltdown fragment, when measured on its inner fractured surface, is 15 mm. thick, but 7 mm. of this amount represents the great crest of bone (*i.f.c.*, fig. 216, A) which projects inwards between the right and left halves of the brain. The degree to which this crest projects inwards can be estimated from the sections given in fig. 216. The inner or deep margin of the Australian and English frontal bones correspond to the inner surface of the Piltdown fragment ; all that lies within the deeper margin of these bones represents substance of the crest. The internal frontal crest was also of great depth and strength in the Boskop skull, in which the forehead was even more upright than in the Piltdown specimen. It will be seen,

too, that the supra-orbital ridges were much less developed than in the Australian frontal bone (fig. 216, A, *glab.*). The sections represented in fig. 216 show us that the forehead and orbits of Piltdown man obtained their strength from the thickness of their bony walls and by the develop-
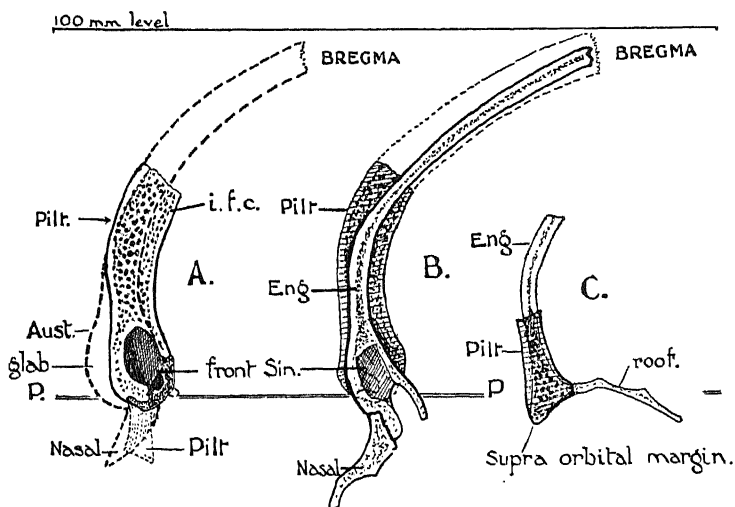
FIG. 216.

A. A vertical section of a frontal fragment of Piltdown man superimposed on a corresponding section of the complete frontal bone of a male Australian aborigine which is represented by broken lines.

  P.P., Subcerebral plane; the upper horizontal line represents the 100-mm. level. *i.f.c.*, internal frontal crest; *glab.*, glabella; *front. sin.*, frontal sinus.

B. Vertical section of the frontal bone of a modern Englishman superimposed on the Piltdown frontal fragment. The missing part of the Piltdown bone is filled in by stippled lines, the extent being estimated from the dimensions of the reconstructed skull.

C. Vertical section of the outer or supra-orbital part of the Piltdown frontal fragment, superimposed on a corresponding section of the frontal bone of an Englishman.

ment of an internal frontal crest, and not by external supra-orbital buttresses, such as we find in Australian natives, in Rhodesian man, and in Neanderthal man.

The impress for the attachment of the nasal bones can still be recognised in the Piltdown fragment. Hence, in fig. 216, A, I have introduced their outline, taken from a drawing in Sir A. Smith Woodward's second paper.

They are of the same shape and size as the nasal bones of Australian aborigines—being unlike the corresponding bones usually present in modern Europeans (compare fig. 216, A, B).

One other point may be mentioned here, raised by the mistake I made regarding the sex of the test skull—that of an ancient Egyptian woman. In every race of mankind there occur men with a rather feminine conformation, and women who, in form of face and thickness of neck, are rather masculine in character. In every collection of a hundred human skulls there are eight or ten of doubtful sex. Does the Piltdown specimen belong to this undeterminate group ? We cannot tell until we have more than one specimen at our disposal. The size of the mastoid process suggests a male, but the small area for the attachment of the neck is strongly in favour of the skull being that of a woman. This inference was substantiated in 1915 when a fragment of a second occipital bone was found. In this the attachment of the neck ascends 8 mm. above the level of the cerebellum and blood-sinuses (see p. 625), and is therefore probably part of a man's skull. The small part of the supra-orbital ridge, preserved over the outer angle of the left orbit, is stout, but neither long nor prominent. In the male we expect a greater supra-orbital development than in the female. The supra-orbital ridge of Eoanthropus suggests a woman's rather than a man's skull. The mandible is big ; so are the teeth ; there is a prominently pointed canine tooth. These characters rather suggest a male. But if they are female characters, then in the male we shall find even a greater simian development of the teeth, for amongst the great anthropoids, males are provided with larger and more prominent teeth than females. On the whole, the evidence favours the opinion that the Piltdown skull is that of a woman.

The importance of the small occipital fragment becomes again apparent in the reconstruction of the hinder part of the head (fig. 213). In the test skull part of the suture line for the occipital bone was preserved on the left

parietal bone. The same suture line was also preserved on the occipital fragment of the right side. By reversing the fragment and transposing it from the right to the left side, indications are obtained for the reconstruction of the hinder part of the test head (see fig. 213). In the case of the Piltdown specimen the occipital fragment gives us a clue to the width and backward projection of the occipital region (fig. 214).

The result of our examination of the Piltdown skull in profile has been to emphasise its close resemblance in size and conformation to skulls of the modern type. But there are also differences. Some of these have been mentioned—the thickness of the bones, the form of the angular or malar process of the frontal bone, the lofty character of the frontal bone in the upper part of the forehead. Two other peculiar features require mention. One of these is shown in fig. 214. The temporal line, which commences on the angular process of the frontal bone (fig. 210), ascends vertically for some distance on the side of the Piltdown skull before turning backwards. In all other kinds of human skulls this line bends backwards almost as soon as it begins to ascend. This peculiar feature may be due to a vertical character of the forehead, or to a peculiarity in the form and manner of action of the temporal muscle. As we have just seen, the former supposition proved to be the right one. The other strange feature of the Piltdown skull, as seen in profile, is the vertical disposition of the suture between the occipital and parietal bones (fig. 215).[1]

We have now reached one of the points towards which we have been working. We have examined and verified the contours and measurements of the Piltdown skull from behind, above, and now from the side, with the view of obtaining those measurements which give us a clue to the brain capacity. We have seen that the width of the skull is 150 mm., its length, 194 mm., its auricular height, 117 mm. Before we can apply to these measurements the formulæ which are used for estimating the brain

[1] See also p. 708.

capacity of the modern skull we must make a reduction on account of the thickness of the bones—reducing the length to 190 mm., the width to 140 mm., the auricular height to 112 mm. The formula [1] I am to employ to obtain the brain capacity is that worked out by Dr Alice Lee and Professor Karl Pearson. When this formula is applied the result is $190 \times 140 \times 112 \times 0.4 + 206 = 1397$ c.c. —a brain capacity which is almost the same as that of the Egyptian woman's skull which formed the subject of our experimental reconstruction. The female skulls found in the plague pits of Whitechapel, in the east of London, had, on an average, a brain capacity of 1300 c.c. ; the male, 1477 c.c.[2] The brain capacity of the Piltdown skull is thus above that of the average modern Englishwoman, and below that of the modern Englishman. The actual brain cast, taken from the interior of my earlier reconstruction of the Piltdown skull, measured a little over 1500 c.c., but in my earlier reconstructions I reproduced the wide forehead seen in Sir A. Smith Woodward's model. When a reduction is made on this account, and also because of an overestimate in length, the capacity of the skull of Eoanthropus may be safely calculated as reaching 1400 c.c., an amount equal to the average capacity of modern Europeans. If Sir A. Smith Woodward and I are right as regards sex, then in the male of the Piltdown race we may expect to find a brain capacity of at least 1550 c.c. Such a result is perhaps surprising when we take the simian characters of the lower jaw of this skull into account, and still more unexpected to those who suppose man's evolution has been a consecutive and continuous series of steps upwards to his present estate. We must not infer that the facts are wrong—it is more likely our preconceptions which are at fault.

So far, we have confined our attention to a general survey of the Piltdown head in profile and satisfied ourselves that we are dealing with one which falls easily,

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[1] *Phil. Trans.*, 1899, ser. A, vol. 196, pp. 225–264.
[2] See Dr W. R. Macdonell's researches, *Biometrika*, 1904, vol. iii. p. 191.

so far as dimensions are concerned, within the modern standard. To appreciate its peculiar features we must go farther afield and see how it compares with other ancient types, such as those found at Galley Hill, at La Chapelle-
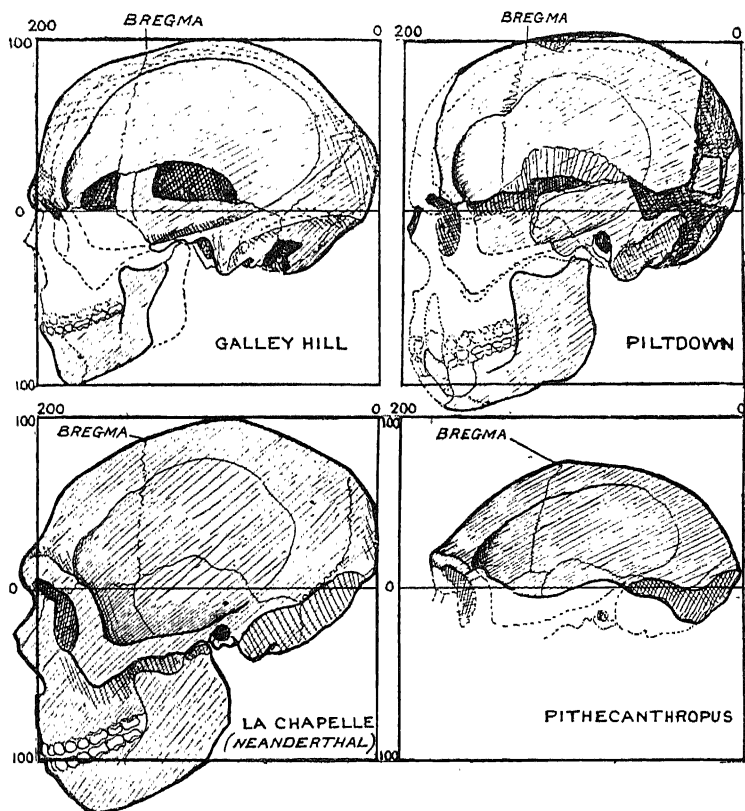
FIG. 217.—Four types of human skulls compared—Galley Hill, Piltdown, La Chapelle-aux-Saints, and Pithecanthropus.

aux-Saints, in Rhodesia, and at Trinil in Java. In fig. 217 are set side by side, within squares of exactly the same size, three of the skulls just named, with the skull of Eoanthropus for comparison. The skull from Galley Hill we may dismiss with a brief note. It represents the modern type of man, and from the analysis just given it will be seen to have many points in common with the skull of

Eoanthropus. As may be observed in fig. 216, there are also many structural points in which they differ. The La Chapelle skull is the largest of the Neanderthal type yet discovered. The big brain which once filled it was living, thinking, and dreaming dreams before the last bout of the glacial period held Central Europe in its grip. When oriented in the same manner as the Piltdown skull, and placed within the same framework of lines, we see (fig. 217) that we are dealing with a man with a massive head. The vault, however, is relatively low, it barely reaches the 100-mm. line ; the great supra-orbital buttress projects 8 mm. in front of the anterior 200-mm. line. We are not surprised when we learn from Professor Boule that the brain of this fossil man measured 1625 c.c.[1] —fully 200 c.c. more than the Piltdown brain, and therefore well beyond the average for modern man. We are not concerned at present with the peculiar attachment of the Neanderthal head to the neck, the absence of the pyramidal projecting mastoid processes, nor the manner in which the inion rises high above our base line (fig. 217). In the Piltdown skull, as in the modern, the inion lies below the level of the base line (fig. 215).

The features on which we shall fix our attention are those relating to the formation of the brain case, so far as the side wall of the skull is concerned.

Five bones enter into the formation of this wall—the frontal, parietal, and occipital along the vault, and two others below, near the base, the temporal and great wing of the sphenoid. The two bones named last merit our attention first. They cover the greater part of the temporal lobe of the brain, and hence give us some clue to its size and development. In the ape's skull (see fig. 208, p. 581) the upper margins of these bones seldom rise more than 10 mm. above the base or standard line. The upper margin of the temporal bone where it overlaps the lower margin of the parietal at the squamous suture is nearly straight. The great wing of the sphenoid is com-

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[1] In *Fossil Men*, 1923, he gives 1600 c.c. as the capacity. The stature of La Chapelle man was 1555 mm. (5 feet 1 inch).

paratively small. All these features are indications of a small temporal lobe to the brain. In the large Neanderthal skull of La Chapelle the upper margin of the temporal bone is more curved than in the ape, and rises 20 mm. above the base line. The great wing of the sphenoid attains a wide development. In modern skulls, and particularly in the ancient one from Piltdown, the upper margin of the temporal is highly arched ; it rises about 30 mm. above the base line. In the Piltdown skull we know that the great wing of the sphenoid must have been of wide extent, for the impress it has left on the lower margin of the parietal and of the frontal bones is 35 mm. long, and clearly demarcated (fig. 215). The great wing of the sphenoid is larger than in modern skulls of a moderate capacity. A survey of those features alone is sufficient to make us realise that the Piltdown race was in some respects highly evolved—at least had departed widely from simian lines of evolution.

In order that the reader may have an opportunity of comparing the profiles of a complete set of ancient types, I have included the most primitive form of fossil skull to which the term human can be applied— that of Pithecanthropus. The geological evidence leads us to believe that Pithecanthropus—the erect, ape-like man of Java—was almost a contemporary of the English Eoanthropus. When the Java skull is posed and placed within our standard frame (fig. 217), we see at once that we are dealing with a type which carries the human form of skull a long way towards a simian stage. The vault falls 25 mm. short of the 100-mm. line. The highest point of the vault, in place of being a couple of inches behind the bregma as in the other three types of skulls shown in fig. 217, is at or near the bregma as in apes (fig. 208). The glabella is 15 mm. short of the anterior 200-mm. vertical line ; the great wing of the sphenoid is wide as in men, but the upper margin of the temporal bone is low and straight as in apes. Dr Eugene Dubois calculated that the brain capacity of Pithecanthropus was 855 c.c., but in the opinion of the

writer, when due allowance is made for the missing
basal parts of the skull, the capacity may prove to
be somewhat greater — probably a little over 900 c.c.
From a comparison with Pithecanthropus we see that
Eoanthropus is a totally different kind of human being—
one in which the brain development, at least so far as
regards size, has reached a modern standard. How the
Rhodesian man stands to the Piltdown type and to
Pithecanthropus will be seen from figs. 139, p. 395,
153, p. 434.

In this chapter I have kept the discrepancies between
the profile of the Piltdown skull as reconstructed by Sir A.
Smith Woodward and myself in the background. The
differences become very apparent when the original recon-
struction is placed within the standard frame employed
here (fig. 215). The vault, in place of rising to the
100-mm. line, falls 11 mm. short of this level. The low-
ness of the vault in his reconstruction has been already
explained. It is due, as we have seen, to the left parietal
bone being tilted inwards beyond the middle line, thus
depressing the vault of the skull. In his reconstruction
the length of the skull is 190 mm.; in mine, 194 mm.
We shall see when we come to deal with the basal parts
of the skull, that Sir A. Smith Woodward had given the
occipital bone an impossible position, thus contracting
the posterior end of the skull. At the lower end of the
occipital fragment of the Piltdown skull the posterior
margin of the opening or passage for the exit of the spinal
cord from the skull—the foramen magnum—is distinctly
preserved in the Piltdown fragment. Now, even in
modern and highly evolved human skulls the posterior
margin of this opening lies between 30 to 40 mm. behind
a line passing vertically through the ear-hole. In the
original reconstruction this margin is only 21 mm. behind
the ear line (see fig. 262, p. 707). One result of the mis-
placement of the occipital bone is to shorten the base of
the Piltdown skull so much that the space for a pharynx
—the passage-way for air and food—is almost obliterated.
The position of the occipital bone is in reality clearly

indicated. When we transpose the occipital fragment, described in a former chapter, from the right to the left side (fig. 214), and articulate it with the hinder margin of the left parietal bone, we obtain a definite indication of the amount to which the occipital bone enters into the formation of the length of the skull. The lower part of the lambdoid suture is 30 mm. in front of the posterior vertical line in my reconstruction; only 20 mm. in the original. It is in the occipital region that the discrepancy lies as regards the total length of the two reconstructions.

Another remarkable feature of the Piltdown skull as reconstructed in fig. 215 is the height to which the temporal bone rises on the side of the skull. It reaches 40 mm. above the base line—more than can be seen in the very largest of modern skulls. We have always, until now, regarded a high temporal bone as an index of a large brain. The height of the squama of the temporal is not so apparent in Sir A. Smith Woodward's reconstruction, because of the tilting inwards of the temporal bone. As to the place at which the upper margin of the temporal bone comes into contact with the lower margin of the left parietal bone of the Piltdown skull, there is no room for doubt; as regards that point, Sir A. Smith Woodward and I are in absolute agreement. The line and area of contact are shown in fig. 215. The difference of opinion relates to the amount broken off or missing from the temporal bone. A glance at fig. 215 will show that two fragments are broken from the squama of the temporal, one from its upper border and another from its anterior border. So little is missing, in Sir A. Smith Woodward's opinion, that he brings the broken margin of the temporal almost in contact with the anterior inferior angle of the parietal bone; whereas in my opinion an interval or gap must be left here, at least 8 or 10 mm. wide. By articulating the temporal in the manner mentioned, Sir A. Smith Woodward, as may be seen from fig. 215, has left no room for the great wing of the sphenoid. We have already seen that the impress of the great wing on the lower border of the

frontal and parietal bones gives us the most certain information that this part of the sphenoid had an exceptionally wide development. In the next chapter we shall see, from certain markings on the brain cast, that by approximating the temporal too closely to the parietal one of the main convolutions of the temporal lobe has almost been obliterated, and the temporal lobe itself given a distorted form.

The evidence which we obtain from a minute examination of the Piltdown skull in profile confirms the conclusions we reached during a survey of its other aspects. It is a skull with dimensions above the average and with certain peculiar characters, but in its general conformation it does not differ materially from human skulls of the modern type. The characters which mark Neanderthal skulls are all absent.

CHAPTER XXXII

THE BRAIN OF FOSSIL MAN

In the previous chapters I have thrust the tedious and technical details relating to the reconstruction of the Piltdown skull before the reader, but our real objective is to see what sort of brain was enclosed within it. The cranial wall is moulded to fit the brain. Hence when the skull is rightly reconstructed—but not until then—it provides us with a means of telling the size and shape of the brain. So exactly does the brain fill its cavity that the impress of its various parts—of its lobes and convolutions—are preserved. When a cast is taken of the interior of the cranial cavity, we see before us a rough image of the organ which guides mankind through the intricacies of life and reveals the world in which men live. In the case of the Piltdown skull, considerable parts of the cranial walls are missing, yet enough are preserved to show us not only the general form and size, but also to give us definite information relating to the mental capacity of its original owner.

We all agree that a man with a big head or a large brain is not necessarily an exceptionally clever man. Those, however, who have studied the brain as experts are firmly convinced that unless a man has a certain size of brain he cannot think and act as ordinary men do. Professor Elliot Smith is of opinion that a brain must reach a weight of 950 grammes (about 1000 c.c. in volume) before it can serve the ordinary needs of a human existence—before it can become the seat of even a low form of human intelligence. If we accept this definition,

then it is certain that Pithecanthropus—that peculiar fossil form of man from Java—falls below the human limit. His discoverer, Dr Eugene Dubois, has estimated that the brain was about 855 c.c. ; for certain reasons I regard this as rather an underestimate—900 c.c. will probably prove to be nearer the truth. In size of brain anthropoid apes fall far below the human level. A gorilla has been found to have a brain capacity of 610 c.c. ; in an exceptional chimpanzee it was as low as 290 c.c. In the majority of great anthropoids—orangs, chimpanzees, and gorillas—the capacity fluctuates between 400 and 500 c.c. Amongst modern human races the brain is found to vary in size ; it may be as low as 950 c.c. or as high as 1900 c.c. The late Sir William Flower divided human skulls into three sizes—small or microcephalic, medium or mesocephalic, and large or macrocephalic. In this manner of classifying skulls an individual with a brain space of less than 1350 c.c. falls into the microcephalic group ; if above 1450, into the macrocephalic group ; if between these, he falls into the medium-headed group. Thus, including all the races of mankind in our survey, we are prepared to regard those with a brain measuring between 1350 c.c. and 1450 c.c. as having reached the standard brain size of modern human races. Suppose, then, the Piltdown man,[1] who lies six or eight thousand generations behind us, were to reappear among us in the flesh, to what group would he be attached ? If we take Sir A. Smith Woodward's original estimate of 1070 c.c., then he is microcephalic and falls almost to the limit which lies between the lowest human and the highest prehuman brain capacity. A brain cast was made from the Piltdown skull by Mr Barlow. When this cast is measured, it is found to displace 1195 c.c. of water ; in round numbers, then, the size of the brain, even when the cranial fragments overlap their normal positions, measures 1200 c.c.—thus reaching a middle place in the small-headed group. When the first edition

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[1] Although I am of opinion that the Piltdown skull is that of a woman, I think it better, in the present state of our knowledge, to speak of its original owner as being of the male sex.

of this book was being written, another official reconstruction of the skull was exhibited at a meeting of the Geological Society, held on the 17th of December 1913, exactly a year after the famous one mentioned in a former chapter. In the new official reconstruction the hinder end of the skull has been opened out to a very considerable extent. As amended, the cranial capacity cannot fall much short of 1300 c.c. Thus we see the brain capacity of this very ancient man, even in official hands, steadily climbing from the bottom to the top of the microcephalic group of humanity.

The reader will now begin to see why I have taken so much care to verify and prove every step taken in the reconstruction of the Piltdown skull. If my methods are right, if the laws which hold good for skulls in general are applicable at Piltdown, then we must promote this early Pleistocene or late Pliocene man to a still higher group. In the previous chapter we found from the measurements of the skull that the brain capacity should be about 1400 c.c. The original reconstruction assigns the Piltdown individual, as regards mere size of brain, to the small-headed group ; my one gives him or her a good place in the medium-headed group. In either case, the important fact remains that so long ago as the beginning of a former geological period a form of mankind had come well within the human standard of brain size. We could have no better assurance that the antiquity of man is very great. The brain which conceived the need for tools and knew how to shape them out of elephants' thigh bones had certainly reached a medium capacity.

Size of brain, as we have already admitted, is a very imperfect index of mental ability. We know that certain elements enter into the formation of the brain which take no direct part in our mental activity. A person who has been blessed with a great, robust body and strong, massive limbs requires a greater outfit of nerve tracts and nerve cells for the purposes of mere animal administration than

the smaller person with trunk and limbs of a moderate size.   Dr Eugene Dubois [1] and the writer [2] have made endeavours to ascertain how much of the human brain is made up of this purely animal constituent.   An appeal to the conditions found amongst anthropoid apes gives us some assistance in solving the problem.   In size of body man differs very little from the great anthropoid apes ; indeed the male gorilla and orang often attain a weight of 70 or 80 kg. (154 to 176 lbs.), or even more.   With a brain volume of 450 c.c. an anthropoid has a sufficient nerve organisation to undertake the more animal form of its activities.   When the brain reaches a volume of 1300 or 1400 c.c., as in man, we need not trouble greatly about the amount which is due to mere size of body ; it cannot be more than 6 per cent. or 8 per cent. of the whole.   Besides, we have reason to infer that the Piltdown individual was not a Hercules.   We have the impress of the neck preserved on the skull.   The muscles of the neck were not particularly strong, nor was the neck massive as in the gorilla, Rhodesian man, or as in Neanderthal man.   The bones of the skull are thick and massive ; it is possible that the bones of the skeleton were also thick and strong, but the indications preserved on the skull point to rather a moderate development of the muscular system.   We have no reason, then, to regard the brain volume of Eoanthropus as dependent on a massive development of the body.

We now turn from a consideration of the gross volume of the Piltdown brain to survey its particular features—the size and arrangement of the lobes and convolutions. A survey of the original brain cast prepared under the direction of Sir A. Smith Woodward led Professor Elliot Smith to express the following opinion : " Taking all its features into consideration, we must regard this as being the most primitive and the most simian human brain

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[1] *Report of the Fourth International Congress of Zoologists, Cambridge,* 1898, p. 78. *Konin. Akad. van Wetensch. te Amsterdam,* 1914, vol. xvi. p. 647.

[2] *Journ. Anat. and Physiol.,* 1895, vol. ix. p. 282.

so far recorded." [1] Such an opinion cannot be lightly brushed aside ; it must command our respect and also our most careful consideration. Unfortunately, our knowledge of the brain, greatly as it has increased of late years, has not yet reached the point at which we can say, after close examination of all its features, that its owner had reached this or that mental status. The statement which Huxley made about the ancient human skull from the cave of Engis still holds good of the brain : " It might have belonged to a philosopher or might have contained the thoughtless mind of a savage."

That is only one side of our problem ; there is another side. Huxley's statement refers to the average brain, which is equal to the needs of both the philosopher and the savage. It does not in any way invalidate the truth that a small brain with a simple pattern of convolutions is a less capable organ than the large brain with a complex pattern. If, then, we find a fairly large brain in the Piltdown man, with an arrangement and development of convolutions not very unlike those of modern man, we shall be justified in drawing the conclusion that, so far as potential mental ability is concerned, he had reached the modern standard. We must always keep in mind that accomplishments and inventions which seem so simple to us were new and unsolved problems to the pioneers who worked their way from a simian to a human estate.

For the interpretation of the brain casts of ancient man we must carry with us a comparable image of a modern brain. The brain cast represented in fig. 218 is taken from the skull of an Australian native ; the capacity of the skull was 1450 c.c. The type specimen we are to use lies on the border-line between the medium and large-headed groups of humanity. The fissure of Sylvius is clearly visible on the cast ; it separates the temporal lobe below from the two great upper lobes—the frontal and the parietal. On the brain cast the central fissure which

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[1] The late Professor Symington has criticised this verdict and other statements made in Professor Elliot Smith's report on the original Piltdown endocranial cast, *Journ. of Anat.*, 1916, vol. l. p. 112.

separates the frontal from the parietal lobe is indistinctly
marked, but its situation can be fixed with a fair degree
of certainty.   A fourth lobe, the occipital, lies behind ;
a depression represents the parieto-occipital fissure (see
fig. 218), which marks the small occipital lobe off from
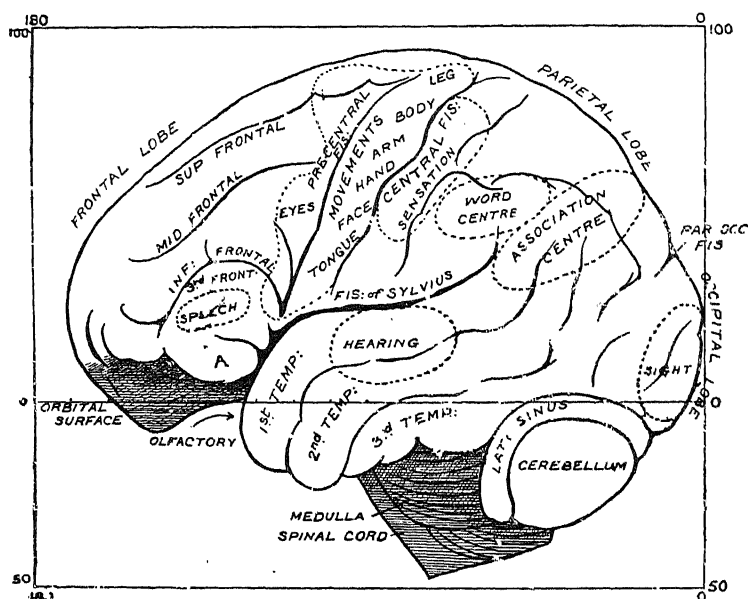
Fig. 218.—Diagram made from a brain cast of an Australian native, with a
   capacity of 1450 c.c.   The divisions between the various lobes and
   convolutions of the brain have been emphasised.   The functional
   values of various parts are indicated.   *1st, 2nd, 3rd temp.*, the three
   convolutions of the temporal lobe.

the parietal.   Below, the occipital lobe becomes united
with the temporal lobe.

Of those four main lobes of the brain just enumerated
the frontal deserves our first consideration.   It consti-
tutes a large and important part of the brain.   On its
lower surface is seen the hollow impression formed by the
roof of the orbit ; on the rounded lateral and upper
surfaces which lie under the forehead can be detected at
least three longitudinal elevations separated by irregular
shallow depressions.   The elevations indicate the upper,

middle, and lower frontal convolutions. The lowest or third frontal convolution is very well marked ; it overlies the hollow caused by the roof of the orbit, and is separated from the temporal lobe by the stem or beginning of the fissure of Sylvius. Now the inferior frontal convolution is of particular importance for our present purpose ; it attains a large and special development in the human brain. In the anthropoid brain, on the other hand, it is not large, nor does it possess the human conformation. At the present time we regard the main mass of this convolution as one of the parts of the brain directly concerned in speech. The exact rôle it plays in thinking and speaking we are really not quite certain about. But we may say, if this part of the brain is found developed in any race of ancient man, that such a race possessed at least the potentiality, if not the actuality, of speech.[1] As to the functional value of the upper and middle frontal convolutions, we are at present not in a position to offer any certain opinion. These convolutions, particularly in their lower or anterior parts, attain a much greater development in man than in the anthropoids, and we are justified in believing that they do take an active part in carrying on the highest functions of the brain—in the formation of judgments and in the regulation of conduct.

Behind the three frontal convolutions just named lies an important area of the brain. In this area descends the central fissure—the boundary between the frontal and parietal lobes. Just in front of the central fissure is the pre-central area, concerned in the movements of the body. In the lower part of the pre-central convolution, just above the fissure of Sylvius, lie the centres for the tongue, lips, and face, close to the third frontal lobe, which is connected with speech. In the pre-central convolution we meet with cortical areas

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[1] At one time it was believed that part of the third frontal convolution (Broca's area) was a " speech centre." It is now recognised that speech involves the action of a number of brain areas, particularly the part of the temporal lobe which has to do with the recognition of sounds and the attaching of meanings to them.

or centres for the hand, arm, body, and leg, arranged in a definite sequence from below upwards. In front of the areas more directly concerned in exciting and controlling the muscles lie other areas—association areas—probably concerned in treasuring up memories of how certain acts are performed. These association areas extend to the hinder ends of the upper, middle, and lower frontal convolutions.

Below the fissure of Sylvius lies the temporal lobe, on which three convolutions — the first, second, and third—can usually be recognised with great distinctness. The functional value of the two lower, the second and third, is scarcely known to us. But in the upper convolution is situated the centre of hearing—that part of the brain which receives messages from the ear, and apparently treasures the memory of sounds and associates particular sounds with particular meanings. This part of the brain must also be regarded as concerned in speech.

The occipital lobe, the projecting hinder part of the brain, is connected with sight. On the occipital pole itself, and on the surface which lies buried in the fissure between the two hemispheres of the brain, is the area where impressions streaming in from the eyes reach the horizon of our consciousness. Spread out on the surface of the brain, in front of the visual area of the occipital pole, are association areas—evidently connected with the elaboration and interpretation of the visual impressions which reach the brain. The parietal lobe constitutes the central part of each hemisphere of the brain; it lies behind the frontal lobe, above the temporal, in front of the occipital. The part of the parietal lobe lying just behind the central fissure—the post-central convolution—receives sensory impressions coming from the skin and body generally (fig. 218), but the greater part of this lobe seems to serve the higher purposes of the human brain—the purposes of memory and interpretation. For instance, the part which lies above the hinder end of the fissure of Sylvius appears to be concerned in the interpretation

of written or printed words. At least, in many cases of " word-blindness "—cases where words can be read but not understood—this area of the parietal lobe is found to have been destroyed by disease. The " word-interpreting " centre is placed in this association area, which often rises above the surrounding parts of the brain into a distinct elevation or eminence. Enough has been said to show that, imperfect as our present knowledge of the brain is, we may hope to obtain some light on the mental status of fossil man by a careful study of brain casts. Indeed, I firmly believe that the day will come when we shall be able to estimate the functional value of every convolution of the brain.

Having thus formed a broad picture of the chief features to be seen on the brain cast of a modern skull, we are in a position to apply our knowledge to casts taken from fossil skulls. It will be well, however, to have a clear idea of a simple and primitive brain, such as is seen in the highest of anthropoids—the gorilla. In fig. 219, I have set a profile drawing of the brain cast taken from the skull of a young gorilla on the same aspect of the cast of the Gibraltar skull—the smallest of the ancient human skulls. Both were drawn on the same scale and poised on corresponding planes. The superimposition of the two drawings is an easy matter, for they have both the same general form—they are flattened as if the vault had been compressed towards the base. The fissure of Sylvius of the ape is laid over the same fissure of the human brain. The triangular hollow between the temporal lobe and the cerebellum, filled in life by the part of the temporal bone which contains the ear, is also superimposed. The superimposition of these two drawings shows us that in the evolution of the brain from a simian to a human stage all the lobes and convolutions were involved. There has been a general and extraordinary elaboration of all parts. The parietal lobe has been affected most ; the temporal lobe least. We know something of the nature of the changes which have occurred. While enumerating the lobes of the brain, we

noted that certain areas or centres were primary—the areas for sight, hearing, common sensation—and that round the primary areas, association areas had arisen. It is the expansion and elaboration of these association areas —complex mechanisms built up of nerve cells and nerve fibres adjusted to serve definite purposes—which raises the
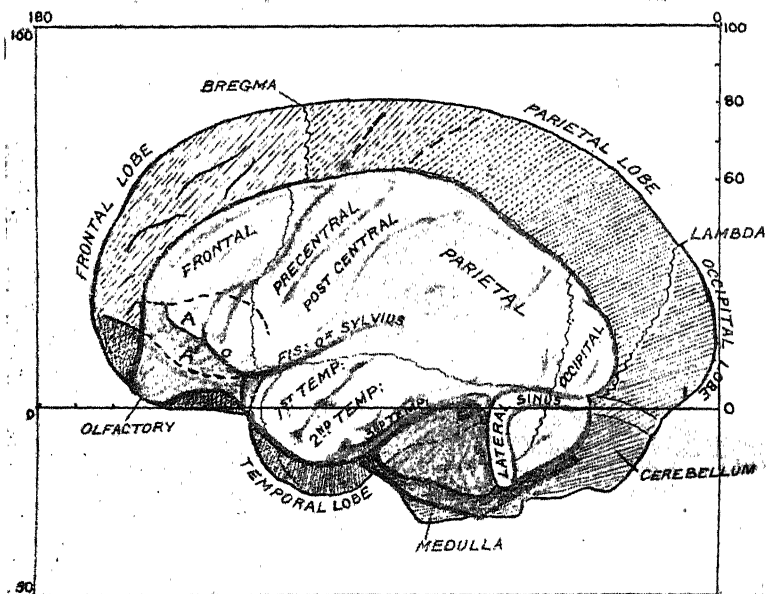
FIG. 219.—Profile drawing of the brain cast from the skull of a young gorilla superimposed on a corresponding drawing of the cast from the Gibraltar skull. The Gibraltar cast exceeds that of the gorilla in all dimensions.

human above the simian brain. In this expansion the simple arrangement of convolutions has been replaced by a more elaborate and complex one. In the last two months of fœtal life the human brain passes from a stage in which the convolutions of the brain have a simple, somewhat anthropoid arrangement to the more complex human form. Even amongst modern people the degree to which the simple arrangement is replaced by the more complex varies very widely. It is highly probable that

these later changes of the fœtal brain may represent the later stages in the evolution of the human brain.

While the passage from the simian to the human stage of development has affected every lobe of the cerebrum and of the cerebellum, there is one part which has undergone a peculiar change, one which is often fore-shadowed to a slight degree in the anthropoid brain. The change concerns the lowest part of the frontal lobe —the inferior or third frontal convolution. The actual part concerned is marked on the gorilla brain in fig. 219 by the letter A. In the human brain this part has grown and expanded to such an extent that it reaches right back to the stem of the fissure of Sylvius, forming the anterior boundary of the stem (fig. 218, A). The old lower boundary of the third frontal convolution (below *o* in fig. 219) becomes included above the new development of the third frontal convolution, and in the human brain forms an intrinsic part—the anterior ramus or branch of the Sylvian fissure (fig. 222, A.R.). It is in this manner that Professor Elliot Smith explains the changes which have occurred in the evolution of the third frontal convolution of the human brain.[1] The change is especially remarkable when we remember that this new *orbital* part of the frontal lobe is related to the faculty of speech.

When we turn to an examination of the Piltdown brain cast we naturally focus our attention on the third

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[1] In this matter and in others, the reader, if he wishes fuller informa-tion on the brain of fossil man, should consult the following papers by Professor Anthony : " Le système operculaire supérieur du Complex Sylvien," *Bull. et Mém. Soc. d'Anthropologie de Paris*, October 1912, p. 294 (with Dr de Santa Maria) ; " L'Encéphale de l'homme fossile de la Quina," *ibid.*, March 1913, p. 117 ; " Le cerveau des hommes fossiles," *ibid.*, 1923, vol. xiii. p. 55. In the same publication for 1917 (vol. vii. pp. 117, 175) appears an excellent series of articles on the brain by Dr E. Landau. Professor Elliot Smith's account of the brains of anthropoids will be found in the *Catalogue of the Museum of the Royal College of Surgeons of England*, Physiological Series, vol. ii. 1902. For his description of the endocranial cast of Piltdown man, see *Quart. Journ. Geol. Soc.*, 1913, vol. lxix. p. 145 ; *ibid.*, 1917, vol. lxxiii. p. 7.

frontal convolution. We at once see (fig. 220) that as regards size and general conformation it reaches the human standard. In Sir A. Smith Woodward's reconstruction (fig. 221) this convolution appears even larger than in mine, because the upper part of the frontal lobe
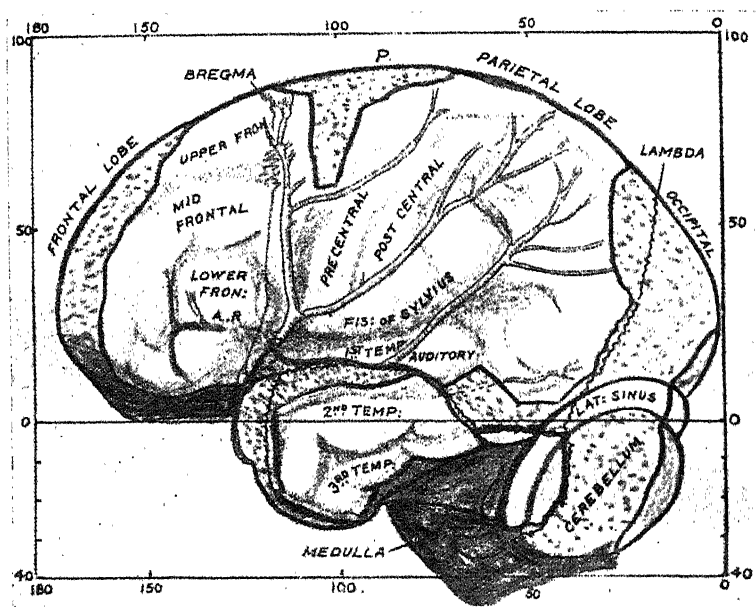
FIG. 220.—Profile drawing of the brain cast taken from the reconstruction of the Piltdown skull by the Author. It is represented half size and set within a standard frame of lines which permits direct comparison between the various drawings given here. The positions of the sutures between the containing bones are indicated. The missing parts are stippled.

has been tilted beyond the middle line, thus exposing more of the lower or orbital surface of the convolutions. A comparison of either of these drawings with fig. 222, which represents a brain cast from the skull of an Australian native, with a capacity of 1450 c.c., shows that the ancient man of Sussex is little, if any, the inferior of the modern Australian. In all three brains one can see a depression indicating the anterior ramus (A.R. in figs. 220, 221, 222). In the ape's brain, it will be remembered,

this branch of the Sylvian fissure is not included within the third frontal convolution, but forms its lower boundary. In the Gibraltar brain cast (fig. 223) the third frontal convolution is smaller, and the anterior ramus, although it was probably present in the actual brain, is not apparent on the cast. So far as concerns the third frontal convolution of the Piltdown brain, there is nothing to suggest that it represents a very primitive human state. It is true that it is more depressed, more excavated, as it approaches the fissure of Sylvius than it is in modern brains, but this compression is due, as I suppose, to the massive buttress of bone which apparently pressed within the commencement of the fissure of Sylvius. If our present conception of the function of the orbital part of the third frontal convolution is well founded, namely, that it takes a part in the faculty of speech, then we have grounds for believing that the Piltdown man had reached that point of brain development where speech had become a possibility and his skill as an artificer increases the probability. It is only when we note the lower jaw and the projecting canine teeth, especially as first portrayed, that one hesitates to allow him more than a mere potential ability. This area of the brain reaches almost as high a development in the Rhodesian endocranial cast as in the Piltdown.

It is convenient now to direct our attention to the temporal lobe, which is separated by the stem of the fissure of Sylvius from the inferior frontal convolution. We have two reasons for taking our survey of the brain in this order: (1) because part of the first temporal convolution is directly concerned with the sense of hearing, and in the interpretation of sounds and words; (2) because we here meet with one of the chief discrepancies between Sir A. Smith Woodward's and the writer's reconstruction of the Piltdown skull and brain cast. In the Gibraltar brain cast, one of the most primitive representations of the human brain yet found in fossil man, one clearly recognises the three temporal convolutions—the first, second, and third (fig. 223).

In the gorilla brain cast they are also apparent: the third or lowest is small and but slightly represented on the lateral aspect of the skull (fig. 219). In the cast of the Australian brain the three temporal convolutions are apparent (fig. 222). In these brain casts, the first convolution passes along the whole length of the lobe,
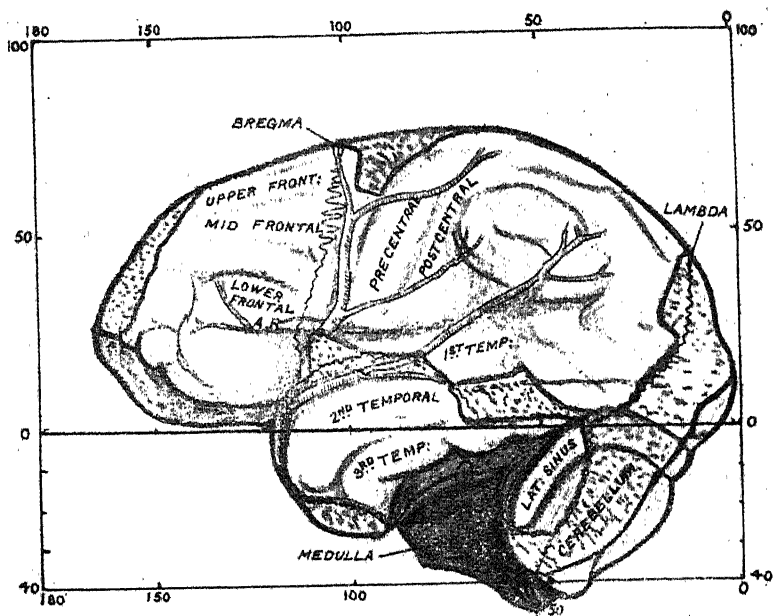
FIG. 221.—Profile drawing of the original cast of the Piltdown brain. The missing parts are stippled and the positions of the suture lines are indicated. To facilitate comparison with other brains, the drawing is set within a standard frame of lines.

on the lower side of the fissure of Sylvius. When the temporal region of the original reconstruction of the Piltdown brain cast is examined (fig. 221), an anomalous arrangement is seen in the first temporal convolution. The impress of the posterior or upper part of this convolution is well preserved beneath the left parietal bone. On the part preserved there is a well-defined eminence marking the area connected with hearing—the auditory eminence. Towards the lower part of the

.temporal lobe—in the region of the stem of the fissure of Sylvius—the first temporal convolution is represented by a narrow area, less than 8 mm. wide, lying between the second temporal convolution and the orbital part of the third frontal. It would be a very remarkable
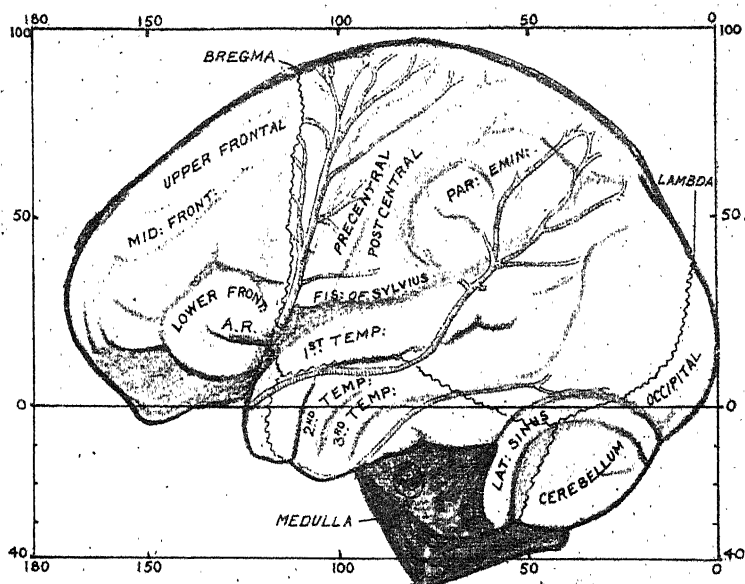
FIG. 222.—Profile drawing of the brain cast from the skull of an Australian native, with a capacity of 1450 c.c. It will be observed that the vessels seen on the surface of the brain cast—the meningeal vessels— are arranged exactly as on the Piltdown brain cast. The positions of the furrows between the brain convolutions and of the sutures between the overlying bones are indicated.

condition if the second and third temporal convolutions were so well developed as they are in the Piltdown brain, and the first reduced to such a narrow limit at its anterior end. The explanation I offer of this anomaly is that in articulating the temporal bone, which contains the greater part of the temporal lobe of the brain, Sir A. Smith Woodward tilted it too far forwards. The great wing of the sphenoid was prevented from taking its due share in the formation of the wall of the brain cavity.

When the sphenoid is given its fair share, as in fig. 220, the abnormal contraction of the first temporal convolution disappears. Indeed, if the restoration just suggested is the right one, then the temporal lobe of the Piltdown brain differs very slightly, if at all, from the corresponding
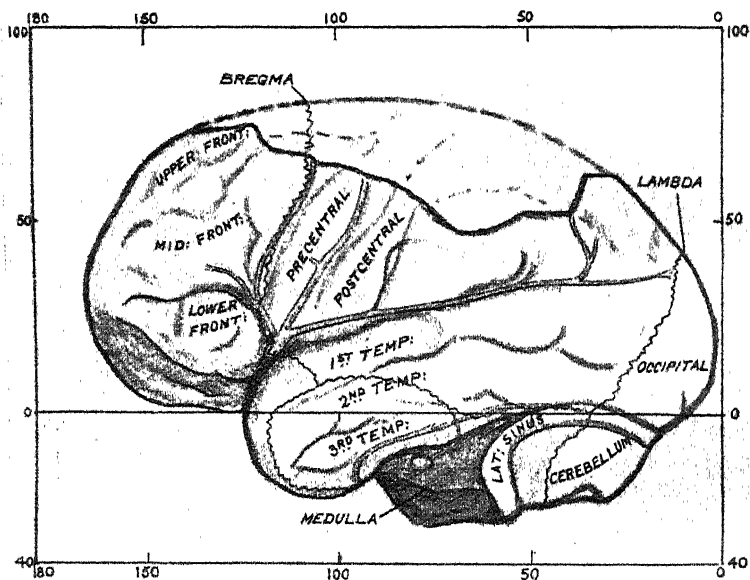
FIG. 223.—Profile drawing of the brain cast of the Gibraltar skull. It represents the smallest known brain of the extinct Neanderthal race.

lobe in the brain cast of a modern native Australian or of an average European.

When the temporal bone is articulated as in fig. 220 another feature disappears from the temporal lobe of the Piltdown brain. Professor Elliot Smith has drawn attention to the manner in which this lobe is bent inwards on the base of the brain. The same feature is present, but to a less extent, in the Gibraltar brain cast and in brain casts of anthropoids. We have a reasonable explanation for the sharp inward bend of the temporal lobe in Neanderthal brain casts. In Neander-

thal skulls, as in those of anthropoid apes, the brain chamber is flattened, as if the vault had been compressed towards the base. The shape of the brain explains why the temporal lobe in these cases is bent inwards. In the Piltdown man the sharp inward bend of the temporal lobe results from the manner in which the reconstruction was originally carried out. When the side of the skull is moved outwards so as to bring the parts on the vault into their just relationship with the middle line, and at the same time the temporal bone adjusted so as to give room for the great wing of the sphenoid, the inward bend of the temporal lobe becomes reduced almost to an ordinary degree. Thus a survey of the temporal lobe reveals no really primitive feature. The temporal convolutions were apparently simple in form ; the auditory centre was plainly indicated, and in general mass the convolutions are such as are met with in human brains of medium or even larger size.

In skull reconstruction nothing is truer than that one mistake leads to another, and the effect is cumulative. The malposition of the temporal bone, which led to the partial obliteration of a convolution, also had another consequence, seen in the hinder region of the base of the brain. In a complete brain cast, the stem which prolongs the central nerve system to the spinal cord is represented (fig. 218). The stem, or medulla oblongata, is seen to lie below and also in front of the cerebellum. A triangular interval filled by the petrous part of the temporal bone is seen between the cerebellum and temporal lobe (fig. 222). The direction of the stem is downwards and backwards. In anthropoids, and also to some degree in Neanderthal skulls, the trend of the brain stem is more backwards than downwards (see fig. 219). In the original Piltdown brain cast the trend of the brain stem is the opposite of primitive ; it is directed downwards with a slight forward tendency (fig. 221). This anomalous position of the brain stem is the result of two circumstances : (1) the forward twist given to the temporal bone, and, (2), to the anomalous position given to the occipital bone.

If the brain cast of a modern skull be examined (fig. 222) it will be seen that the hinder part of the stem—occupying the posterior margin of the foramen magnum—lies well behind the mastoid part of the temporal bone. In the original reconstruction (fig. 221) the hinder end of the brain stem is situated directly below the mastoid part of the temporal bone, and at an abnormally low level. This arrangement at the hinder part of the base of the brain gives very exceptional and peculiar features to the original Piltdown reconstruction. The forward position of the occipital bone and brain stem necessarily diminished that part of the base of the skull on which the brain stem rests. Indeed, to such a degree was this part of the base of the skull curtailed, that when the face and palate were restored in the original reconstruction it was found that an altogether insufficient space was left for the pharynx. When, however, the temporal bone is adjusted and the occipital bone placed as it is in modern skulls (see fig. 221), all these anomalies disappear, the brain stem assumes its normal trend, the occipital bone its normal relationships, and an ample space is provided for the passage of food and air along the pharynx. So far, then, we have seen no feature of the Piltdown brain to which we can apply with any certainty the term of primitive or simian. All the characters we have encountered are not very unlike those seen in modern skulls and brains.

We have confined our attention to the parts of the brain near the base. When we pass to the region covered by the vault and examine such indications as are apparent on the frontal and parietal lobes, our statements become less certain. The two upper frontal convolutions, so far as they are preserved, were apparently simple, but not small. The convolution of the central region—where the centres for movement and common sensation have their seat—are not sharply indicated on the cast; they certainly were not highly developed. On the hinder region of the vault the parietal eminence is well marked. In position and extent, the raised convolutions which form this eminence do not differ from those seen in brain

casts taken from modern skulls. I cannot detect any feature in the frontal, parietal, or occipital areas which clearly separates this brain cast from modern ones ; nor can I recognise any feature which has a distinct claim to be regarded as simian or primitive. A survey of the convolutionary regions of the brain leads to the conclusion that we are dealing here with a simple and primitive arrangement of parts ; but not so simple or so primitive as to make us wish to place the Piltdown brain in a class apart from modern human brains. To my mind it appears, even in its convolutionary arrangement, to fall well within the limits of variation seen in modern human brains.

How does the Piltdown brain compare with the Rhodesian ? In the latter case there is no question of reconstruction, and the convolutionary impressions are much more sharply marked than in the Piltdown cast. When we compare the corresponding convolutionary markings of the Piltdown and Rhodesian casts there can be no doubt that the brain outfit of Rhodesian man was less in volume and simpler in pattern than in Piltdown man. As we have seen (p. 390), Rhodesian man, in these respects, scarcely reaches the lowest level of the Australian aborigine. And yet the brain of Rhodesian man was many rungs higher in the evolutionary ladder than that of the Java man (fig. 224, B) ; and this in turn was many more steps higher than that of the gorilla (fig. 224, A). Piltdown man, although outstripped in the scale of brain growth by Neanderthal men, had nevertheless reached a modern level.

We have been studying the brain as it presents itself to us in a side view. A cursory survey of the brain casts from behind will prove instructive at this stage of our inquiry. We are thus provided with an opportunity of surveying both hemispheres of the brain—the right and left—and of dealing with the problems relating to their symmetry. The right and left halves of the body are built so as to match each other, but if we use one side more than the other or differently from the other, then we

expect a certain degree of asymmetry to appear. The
right and left halves will no longer remain exact counter-
parts, either in function or in form. A difference in
form indicates a difference in function. If we are right-
handed, then the right side of the body preponderates.
There is a crossing of the nerve tracts of the body, and
it thus comes about that the right half of the body is
more directly connected with the left hemisphere of the
brain, and *vice versa*. I have never seen a human brain
in which the convolutionary pattern of both sides was
alike. In the human brain there is evidently some
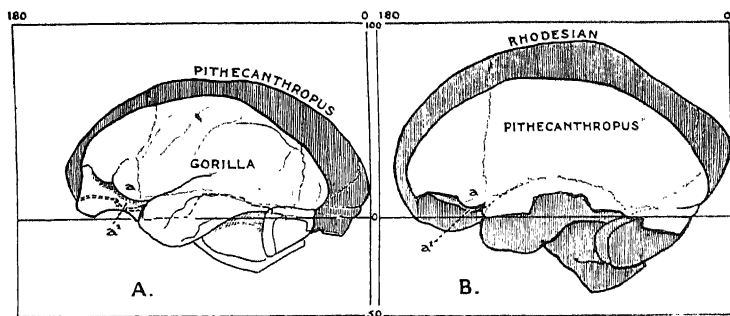
FIG. 224.—A. Endocranial cast from the skull of a young gorilla super-
imposed on that of Pithecanthropus. B. The endocranial cast of
Pithecanthropus superimposed on that of the Rhodesian skull.

degree of specialisation in its two hemispheres. At the
present time we regard perfect symmetry of the two
hemispheres of the brain as indicative of a similarity in
function ; a high degree of asymmetry, if not due to a
disturbance of normal growth, betokens a specialisation
of function. An asymmetrical brain, then, is a specialised
brain, the opposite to the primitive symmetrical brain.

In fig. 225 is represented the occipital or hinder aspect
of a gorilla's brain cast. The right and left sides are
almost alike. The impress of the longitudinal blood-
sinus can be detected along the whole length of the vault
of the brain between the two hemispheres. As it courses
down to the occipital region, it is continued between the
right occipital lobe above and the right half of the

cerebellum below as the right lateral sinus. The left
occipital pole (fig. 225, L.O.) is rather larger than the
right pole. The right half of the cerebellum is somewhat
larger than the left half. There is thus some indication
of a specialisation of function in the occipital region of
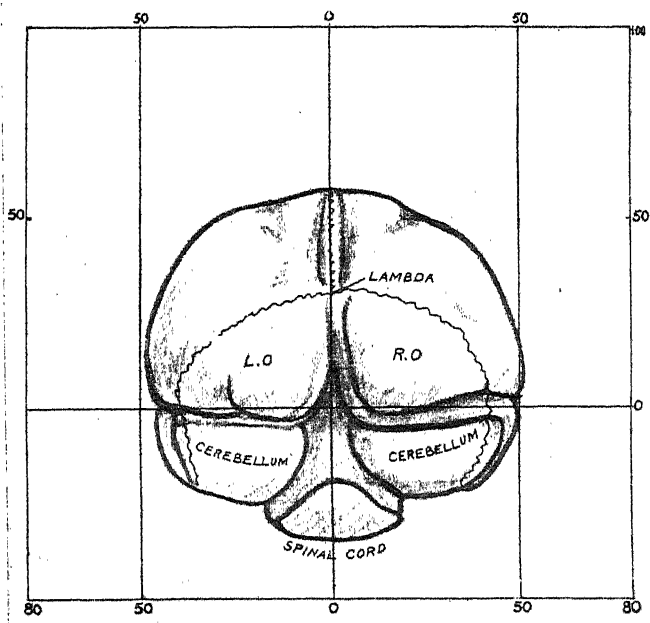
FIG. 225.—The occipital aspect of the brain cast from the skull of a young
gorilla, to show the slight degree of asymmetry of the left and right
sides. The drawing has been set within the standard lines used for
the human brain, so as to give a true comparison as regards size of
the anthropoid and human brain.

even a gorilla's brain—a region connected with the
function of sight. The medulla emerges between the
lateral lobes of the cerebellum to become continuous with
the spinal cord. The outline of the occipital bone is
shown (fig. 225); its right and left halves are approxi-
mately symmetrical. Further, it will be noticed that in
width the gorilla brain just reaches the 50-mm. lateral
vertical lines. In height, the right and left halves of the
cerebrum fail to reach the 60-mm. level.

In fig. 226 the brain cast from an Australian skull—
the same specimen as was represented from the side—is
drawn from exactly the same point of view as was
adopted in the case of the gorilla; there is a marked
contrast in shape and size between the two. The vault of
the modern human brain cast is not flattened from above
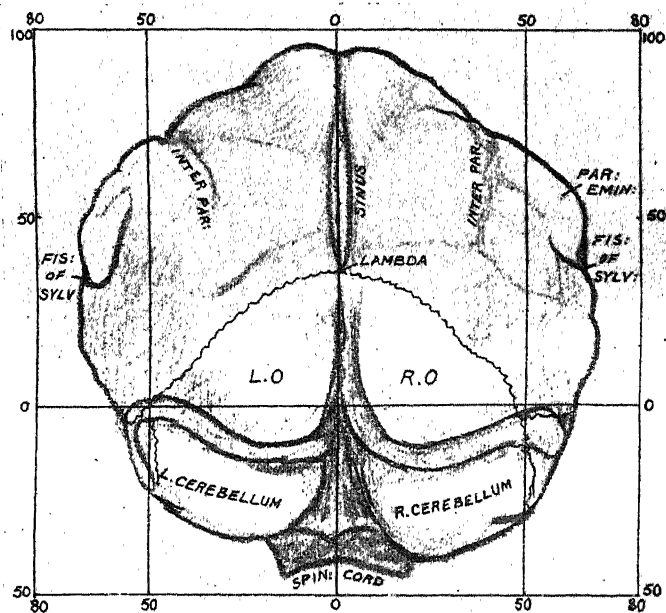
FIG. 226.—Brain cast from the skull of an Australian native (capacity
    1450 c.c.), to show the parts of the brain presented in a view from
    behind.

downwards, as in the gorilla and as in Neanderthal man,
but is lofty and peaked, rising almost to the 100-mm.
level. In the gorilla the sides of the brain cast bulged
outwards, but here, in the Australian brain cast, they are
compressed and reach well beyond the 50-mm. verticals,
almost to the 70-mm. lines. In both, however, there is
about the same degree of asymmetry; the left occipital
lobe and the right cerebellar are the larger. The longi-
tudinal sinus behaves in the same way in both. Before

reaching the hinder ends of the parietal bones, the sinus leaves on the brain cast a long, oval elevation, with a sharply depressed lateral border. Then it passes between the poles of the occipital lobes and turns to the right as the right lateral sinus. It will be noted that the lateral sinus and occipital poles descend well below the horizontal zero line in the Australian brain cast; in the gorilla's brain cast the poles and sinuses are nearly on a level with the zero line. A low position of the occipital poles is a more highly evolved condition. The brain stem has a downward direction in the Australian, whereas its direction is backwards in the gorilla. The right and left margins of the occipital bone are nearly symmetrical.

When we view the original reconstruction of the Piltdown brain cast from behind we are at once impressed by the number of its peculiarities (fig. 226). On the vault of the cast we can observe no trace of those signs which indicate the position and course of the longitudinal blood-sinus, such as are to be seen on the brain casts of anthropoids and men. The natural inference is that the parts of the bone which carried the marks of the sinus have been broken away and are missing. The right and left occipital poles of the brain are nearly symmetrical; each almost reaches the middle line. As in the casts from the gorilla and Australian native, the longitudinal sinus, seen between the occipital poles, turns to the right. Lower down, however, we note one peculiar feature : the right lobe of the cerebellum passes far to the left of the middle line. Further, we know that the ridge on the occipital bone which marks the middle line of the neck lies nearly 10 mm. ($\frac{2}{5}$ inch) to the left of the middle line given to the brain. While the occipital lobes are thus given a primitive symmetrical arrangement, we note that there is a large degree of discrepancy between the right and left halves of the lambdoid suture. On the left side this suture crosses the 50-mm. line [1]—almost as in the Australian cast. On the right side it falls far short of the 50-mm. line ; indeed, to obtain approximate

[1] See fig. 227, P', P'.

symmetry of the two sides the position of the right lambdoid suture must be moved outwards as is shown in fig. 228. To make the right hemisphere of the brain match the left, it must be moved outwards to the position of the stippled line shown in fig. 227. A survey of those anomalous features leads us to the conclusion
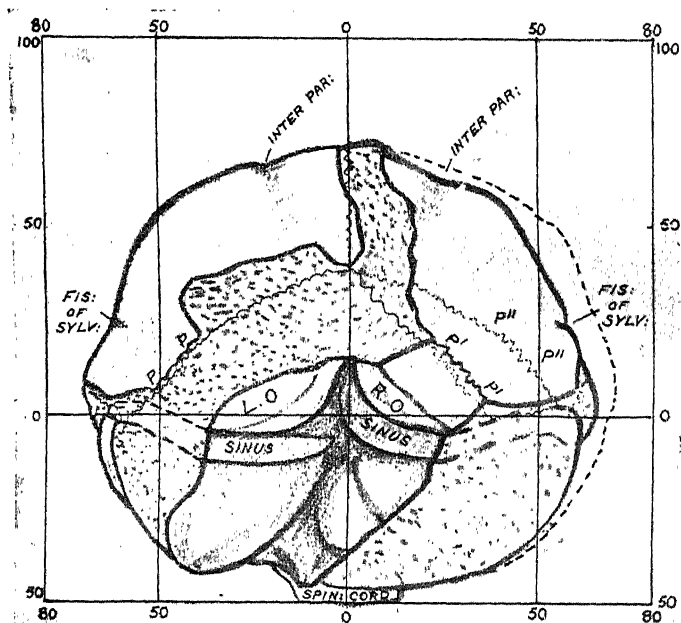
FIG. 227.—An occipital view of the original brain cast of the Piltdown skull. On the right side the stippled line indicates the degree of expansion required to make the right hemisphere of the brain symmetrical with the left.

we reached when examining the skull, namely, that they result from faulty reconstruction.

When the fragments of the cranial cast are adjusted as in fig. 228, the size and form of the Piltdown brain undergoes a considerable change. The brain cast is now comparable in all its parts with those taken from modern skulls. Only one trace of the longitudinal sinus on the vault is visible—the sharp, inward depression at the upper angle of the left parietal fragment. There is no

escape from the fact that a high degree of occipital asymmetry is present, such a degree as is only seen in modern skulls with a considerable brain capacity. While working in Egypt, amongst the crania of the ancient inhabitants of that country, Professor Elliot Smith and Professor Wood Jones found that individuals who showed in their skulls this high degree of preponderance of the left occipital pole also showed marked evidence of a specialisation of the right hand and right side of the body. The man who chipped the eoliths which lay beside the skull in the Piltdown gravel, to say nothing of the bone implement, evidently had reached a high degree of right-handedness. While investigating the peculiar preponderance of the left occipital pole in modern skulls, I was struck by the fact that it is accompanied by a corresponding asymmetry in the lambdoid suture. On the left side the lambdoid suture in such skulls crosses the 50-mm. line higher up and passes farther beyond it than on the right side. In fig. 228 the left occipital lobe of the brain is given its just preponderance, and the left half of the occipital bone has become more extensive than the right. In the development of the occipital poles of the brain, this early Pleistocene man shows, not a primitive feature, but one which must be regarded as evidence of a fairly high degree of specialisation.

Before leaving the occipital aspect of the skull there are several features to which attention should be drawn. It will be observed (fig. 228) that the lateral sinuses fall almost on the horizontal zero line—a primitive character. A second point worthy of notice is that while the original brain cast (fig. 227) is given the flattened form with which we are familiar in the brain casts of anthropoids and of Neanderthal men, the other reconstruction has assumed a form very similar to that found in brain casts taken from modern skulls (compare figs. 226 and 228). The most important feature to be noted, however, is the general enlargement of the brain which results from the opening out of the vault of the skull in order that the various parts may be brought into their proper relationships to

the middle line. The opening out of the vault completely alters our estimate of the Piltdown brain. In the original cast (fig. 227) the parietal eminences are situated almost on the upper aspect of the vault; the interparietal depression approaches within 20 mm. of the middle line of the vault. When the vault is opened out, the parietal
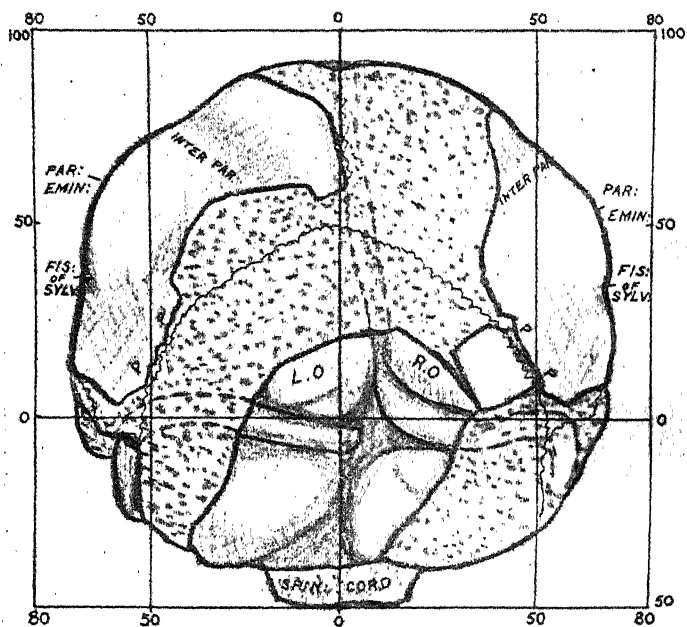
FIG. 228.—Occipital view of the Piltdown brain cast as restored by the Author.

eminences and interparietal depressions assume almost the same relationship as in modern man (compare figs. 226 and 228). We have seen that the parietal lobe of the brain—of which the eminence forms a central part—is the seat of higher or association centres. The anomalous closing of the vault in the original brain cast deprived Piltdown man of a very large area of the parietal lobes— deprived him of one of the areas which are characteristic of the human brain.

There is still another aspect of the brain we must examine before we are in a position to give a definite opinion on the cerebral endowment of fossil man. In fig. 229 a view of the upper or vault aspect of the brain
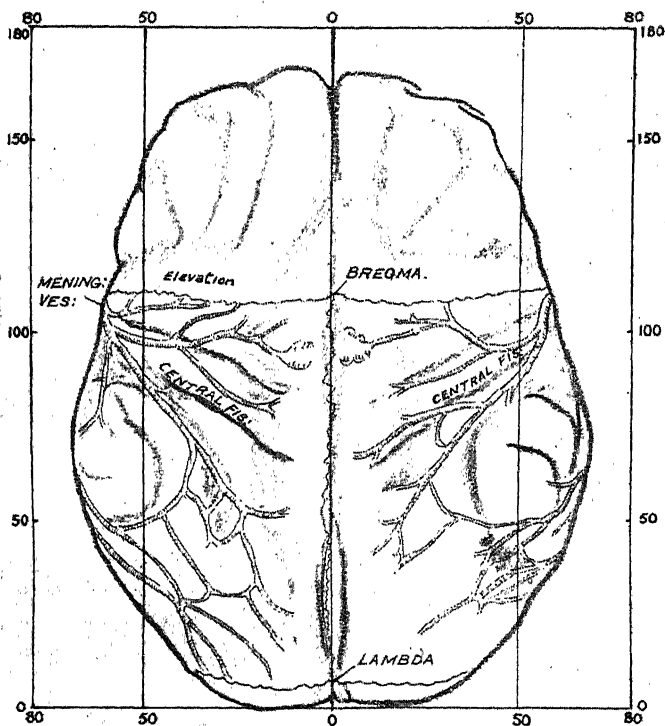
FIG. 229.—View of the upper aspect of a brain cast taken from the skull of a native Australian.

cast from the skull of a native Australian is represented. It is especially important to note the various features seen along the middle line of the vault from front to back, for much of the difference of opinion regarding the Piltdown brain centres round a correct identification of the middle line. In the Australian cast the middle line at the very front of the vault is marked by a groove between the right and left frontal lobes. Very soon, however, this

groove, in which the longitudinal sinus lies, disappears, and is replaced, before the bregma is reached, by a wide elevation or ridge on which no distinct impress of the median blood-sinus is visible. This median frontal elevation, with a slight groove running along its summit, is continued backwards under the anterior two-thirds of the parietal bones. There, the wider elevation disappears, and is replaced by a narrow, oval ridge—the first clear trace of the great longitudinal blood-sinus to be seen on the vault of the brain cast. A little distance in front of the lambda this narrow, well-defined ridge disappears. The wider elevation, running along the middle line of the vault in front of, and behind, the bregma, is caused, not by median convolutions of the brain, but by a remarkable vascular arrangement of which the longitudinal sinus forms the main part. The median elevation is a vascular not a convolutionary impression.

The next brain cast we propose to examine on the upper aspect is taken from the Neanderthal calvaria (fig. 230). It has a particular interest for us in solving the problem of man's antiquity. It represents the brain of a remarkable and very ancient type of humanity which we suppose to have died out soon after the middle of the Pleistocene period. A comparison of figs. 229 and 230, representing the modern and ancient forms of brain, at once brings home to us the fact that a large brain is not the monopoly of modern man. Now, when we examine the track of the longitudinal sinus along the vault of the Neanderthal brain cast (fig. 230), we see many points in which it differs from a modern brain cast. In front, we see at first the same depression or groove between the frontal lobe—a depression in which the longitudinal blood-sinus lies. There appears, in front of the bregma, the median vascular elevation seen in brain casts of modern skulls. But behind the bregma the elevation ceases, and the narrow median ridge for the sinus appears, set in a depression or hollow between the raised marginal parts of the cerebral hemispheres. Just in front of the

lambda the ridge caused by the l'ongitudinal sinus shows sharp, lateral, depressed margins of the same kind as we saw in brain casts of modern man.

To make our study of the median line of the brain cast complete it is necessary to examine the primitive
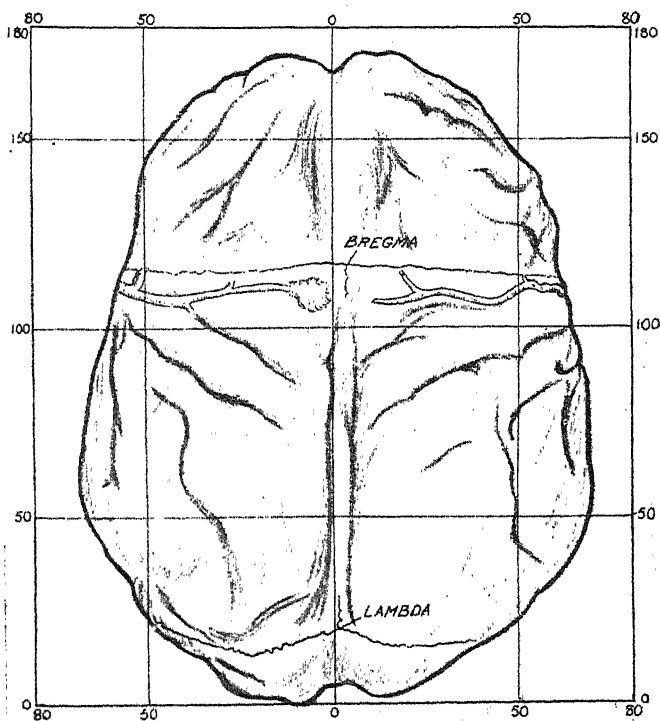
FIG. 230.—Brain cast of the Neanderthal skull viewed from above.

arrangement seen in a brain cast taken from the skull of a young gorilla (fig. 231). In this instance we can trace the impression for the longitudinal sinus, lying in a groove or depression between the adjacent margins of the cerebral hemispheres. The median vascular elevation, which was so apparent in the brain cast of modern man, and to a less degree in that of Neanderthal man, is absent in the bregmatic region. We must suppose, then, that the

primitive condition for the sinus is that represented in the gorilla.

We now turn to the restoration of the Piltdown brain cast (fig. 232) to see if we can recognise any of the indications of the middle line enumerated above. The
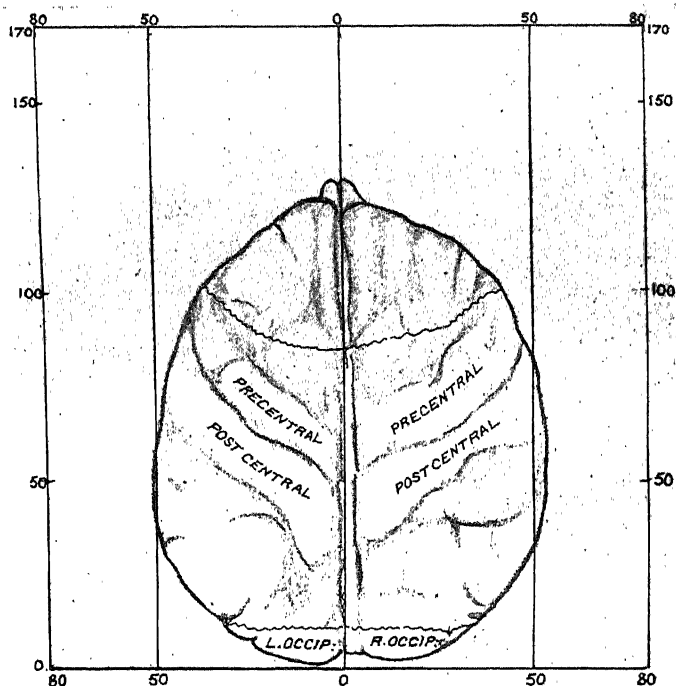
FIG. 231.—Brain cast from the skull of a young gorilla viewed from above, to show the markings for the longitudinal blood-sinus.

first matter to claim our attention is the position of the middle line in the frontal region, for until we have identified this line to our satisfaction we cannot restore the parts to their natural positions. In the original restoration the middle line in the frontal region runs along a median elevation. Is this elevation the vascular one which we have seen in other human brain casts, or is it the margin of the left hemisphere—the upper or first frontal convolution? Undoubtedly it is the latter, for

three reasons. (1) If it is not the first frontal convolution, then this convolution was missing in the Piltdown brain—an improbable supposition. (2) It will be noted that the coronal suture (C.S., fig. 232) crosses this con-
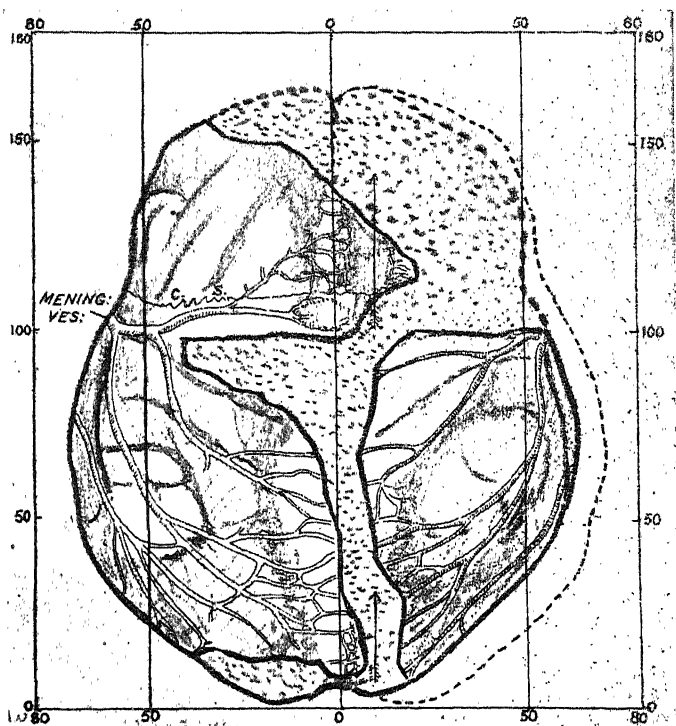
Fig. 232.—Drawings of the Piltdown brain cast as originally restored by Sir A. Smith Woodward. The stippled line on the right shows the extent to which the right fragments must be moved outwards to make the two sides symmetrical. The arrows indicate the true middle line.

volution unchanged in direction, indicating that it has not reached the middle line. (3) If we regard this elevation as lying in the middle line, it is impossible to fit the parts of the skull so as to give the right and left halves an approximate degree of symmetry. To my mind there is no doubt that the shallow groove, marked by an arrow in fig. 232, represents the position of the middle line.

A trace of the marginal elevation of the right frontal lobe is apparent at the point of the frontal fragment. Further, it will be found that at the margins of the lateral sinus of modern skulls, the vessels which supply the skull and outer covering of the brain terminate in a peculiar fringe of fine tributaries. The impress of this vascular fringe is apparent on the left side of the median groove on the original brain cast (see fig. 232). We have evidently to deal with a condition similar to that seen in anthropoid brain casts, where the longitudinal sinus is represented by a groove or depression between the adjacent marginal elevations of the frontal lobes. The median elevation is absent—not yet developed.

At the hinder end of the left parietal fragment of the brain cast we meet another clear indication of the longitudinal sinus. The incurved margin at the hinder angle of the parietal fragment represents the lateral boundary of the sinus to which attention has already been drawn. On the incurved margin can be seen a trace of the vascular fringework already described (fig. 232). If we suppose that the arrow in fig. 232 represents the true position of the middle line in front of the lambda, then all the parts fall into conformity with those seen in brain casts of men and anthropoids.

Thus an examination of the brain cast confirms the conclusion reached from an examination of the skull, namely, that a mistake was made in the identification of the parts lying in the middle line which greatly diminished the real size of the brain, and these mistakes continue to be made! When the parts are readjusted, the brain cast takes the form and size shown in fig. 233. The asymmetry of the two sides has largely disappeared. The arrangement of the meningeal vessels and of the convolutions of the left side are seen to harmonise with those of the right. At the same time the large areas of the brain, representing the higher association centres, are restored, and we obtain a brain primitive in some respects, it is true, but in all its characters directly comparable with that of modern man (compare figs. 229 and

233). Indeed the only features in this ancient brain which seem to me to really differ from modern brains lie in the frontal region. The absence of the median vascular elevation—a simian condition—in front of the bregma has
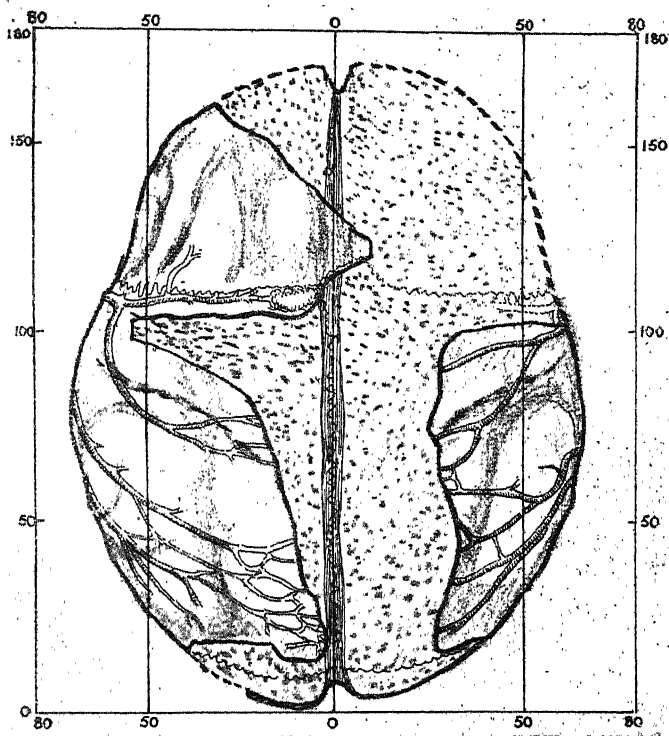
FIG. 233.—Drawing of the upper aspect of the Piltdown brain cast as restored by the Author. The stippled area represents the missing parts—the parts filled in from inference.

been described. There is another feature which I have not mentioned so far. If the figures of the gorilla brain casts are examined (figs. 219, 231, pp. 612, 632), it will be seen that the two central convolutions—in which centres for movement and ordinary sensation are situated—are distinctly raised above the surrounding areas of the brain. In Neanderthal and modern human brains

these central areas appear to be slightly submerged, owing to the areas immediately in front of the motor and immediately behind the sensory areas—true association and therefore higher and later areas—having undergone a special development accompanied by elevation. In the Piltdown brain cast I cannot detect any distinct elevation of the frontal cortex, which lies anterior to the motor cortex. This also must be counted a primitive feature, one which is even more noticeable in the Rhodesian cast.

To some it may seem that I have entered into the reconstruction of the Piltdown skull and brain too elaborately. When it is remembered, however, that this is the first time we have had an opportunity of learning the degree to which the evolution of the brain had progressed in early man at the beginning of the Pleistocene period, it will be apparent that the task deserves our most painstaking endeavour. We are, at the same time, laying the rudiments of craniological grammar. We have here—in the discovery at Piltdown—the certain assurance that one race of mankind had reached, so far as the mass of brain is concerned, a modern human standard at the beginning of the Pleistocene period. All the essential features of the brain of modern man are to be seen in the Piltdown brain cast. There are some which must be regarded as primitive. There can be no doubt that it is built on exactly the same lines as our modern brains. A few minor alterations would make it in all respects a modern brain.

Although our knowledge of the human brain is limited —there are large areas to which we can assign no definite function—we may rest assured that one which was shaped in a mould so similar to our own was one which responded to the outside world as ours does. Piltdown man saw, heard, felt, thought, and dreamt much as we still do. If the implements found in the same beds of gravel are his handiwork, then we can also say he had made a great stride towards that state which has culminated in the inventive civilisation of the modern western world.

THE PILTDOWN MANDIBLE

ALL through the previous chapters we laboured to establish on a sure foundation of fact the size and form of skull and brain of the earliest example of fossil man yet discovered. We have not seen the slightest reason to doubt that all the fragments were parts of the same skull. Further, we did not meet with a single feature in the skull or brain cast which excluded the Piltdown man from our immediate ancestry. During the great span of time which lies between him and us we can well conceive that his brain and skull might have been converted into the forms seen in modern races of mankind. When we come to build up the face our steps are not attended by the same degree of certainty. We have to base our reconstruction on the right half of the mandible. This, with the nasal bones, and parts of the forehead, are all that have been found of the face. Are we certain that the mandible does form part of the same individual as the skull fragments ? There are many who think it highly improbable that the two do go together. From the very first, Professor Waterston [1] expressed grave

[1] *Nature*, 1913, vol. xcii. p. 319. In 1915 Mr Gerrit S. Miller assigned the Piltdown mandible to an extinct species of chimpanzee to which he gave the name *Pan vetus* (*Smithsonian Misc. Coll.*, 1915, vol. lxv. p. 1). Professor Boule was also of opinion that the Piltdown mandible was that of an extinct species of chimpanzee, but further knowledge of the original Piltdown specimens has shaken this belief. Professor Waterston has published recently a paper in support of his contention, *Proc. Roy. Physic. Soc. Edin.*, 1921, vol. xx. p. 211. The distinguished Swedish anatomist, Professor M. Ramström, is of Professor Waterston's opinion, *Bull. Geol.*

doubts regarding the mandible; he regarded the skull as human, the mandible as simian or anthropoid. There are others besides Professor Waterston who regard the mandible as part of an extinct anthropoid. If only the mandible and the teeth had been found—two molar or cheek teeth and the canine or eye tooth—the great majority of anatomists would have regarded the extinct being of which they formed part as more anthropoid than human in nature. But when we take into account (1) that this mandible lay in the same ancient stratum, and at the same spot as an ancient type of man; (2) that as regards proportionate size, texture of bone, degree of fossilisation, it agrees perfectly with the skull; (3) that the molar teeth are essentially human, I think we must regard it as part of the same individual. If we do not, then we have to accept the much greater improbability that long ago there lived in Sussex (1) a true but early form of man; (2) an anthropoid with certain human features in its teeth and jaws; (3) that after death the skull of the one and the mandible of the other came to rest cheek by jowl in the Piltdown gravel. Such an event, of course, is possible, but highly improbable.

On the other hand, that we should find a human form which, in some of its parts, retained or exhibited a marked preponderance of simian characters in such a structure as the lower jaw is not improbable. A close study of the anatomy of man, and of the animals most nearly allied to him, shows many examples of this kind. I can make my meaning more easily understood if I cite a few concrete examples selected from the anthropoid apes which show a very close structural relationship to man. The chimpanzee's teeth are less specialised, more primitive or monkey-like, than those of the gorilla. As regards characters of teeth, man and the chimpanzee have

rather more in common than either has with the gorilla. In the anatomy of the lower limbs the case is reversed. The lower limbs of man are by far the most specialised, but the gorilla's also show several human peculiarities which are absent in the chimpanzee.[1] As regards the characters of the lower limb, we should link man with the gorilla. As regards teeth, we should link him with the chimpanzee. I will cite two other examples which occur to me. In all lower forms of apes the liver is divided by deep clefts or fissures into three main lobes—right, middle, and left. In all the higher primates—man and anthropoids—the triple division of the liver has disappeared and the organ has been unified, in all save the gorilla, in which the tripartite state still persists. As regards the characters of the liver the gorilla may be described as archaic. The last example I am to cite has a more direct bearing on the problem of the Piltdown mandible. In the Neanderthal and Rhodesian races we find the eyebrow ridges shaped as in anthropoid apes; we suppose that in this ancient human race the primitive or anthropoid type of eyebrow ridge has been retained. These examples are sufficient to show that as new forms of men and apes were evolved the incidence of change or of progress on the evolving body was local or patchy, some systems of the body being affected, others being left untouched. The human body is a mosaic in which a myriad of structural patterns has been combined. It is therefore quite possible that we may encounter such forms as that found at Piltdown, in which the characters of one part seem to be at variance with those of another—as the mandible with the skull.

We propose, in the first place, to make a cursory examination of the simian characters of the Piltdown jaw, and to see what significance we must attach to them. Before we set out on such a survey, we must obtain a clear mental picture of the essential characters of a human mandible. In fig. 234, a drawing shows the chief features

[1] See the Author's lectures on the "Evolution of Man's Posture," *Brit. Med. Journ.*, 1923, i. pp. 451, 669.

which mark the inner or mouth aspect of the human mandible. Passing obliquely downwards and forwards on this aspect of the jaw, from just behind the last molar or wisdom tooth above to below the symphysis or union of the two sides of the jaw in front, is a narrow linear ridge of bone marking the line along which the right mylo-hyoid muscle was attached. The left muscle has a similar origin from the opposite half of the mandible.
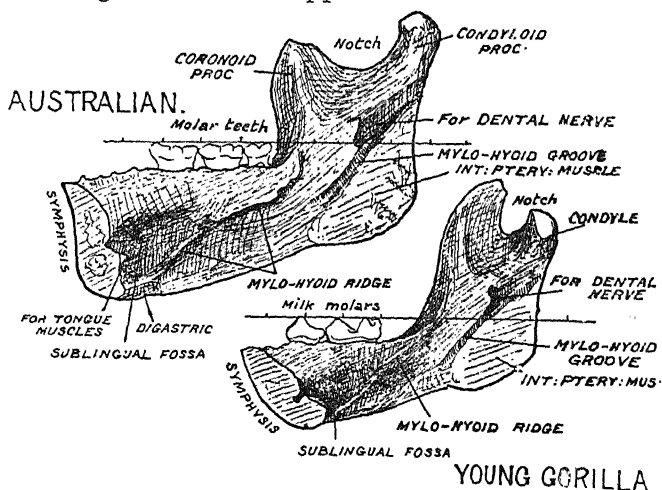
FIG. 234.—Right half of the mandible of an Australian native, viewed from the inner or mouth aspect to show certain human characters. Below it there is represented the corresponding half of the mandible of an infant gorilla, about two years old.

From such origins the two mylo-hyoid muscles unite along the middle line of the floor of the mouth, forming a muscular floor or diaphragm. The tongue rests on this muscular floor. In all acts, such as swallowing and speaking, the mylo-hyoids come into active use in raising the floor and the tongue. The more these muscles are used, the stronger they become and the more do the mylo-hyoid ridges become emphasised and raised on the inner aspect of the mandible. In the more highly evolved races of modern man these ridges reach a very emphatic development. In anthropoids, on the other hand, they are but slightly marked—only the part lying under the

molar teeth being easily recognised (fig. 235). We therefore conclude that a high development of the mylo-hyoid muscle is a human character, and we have also reason for supposing that this high development is more closely connected with speech than with swallowing.

Now, as may be seen from fig. 235, the mylo-hyoid ridge in the Piltdown mandible has the slight develop-
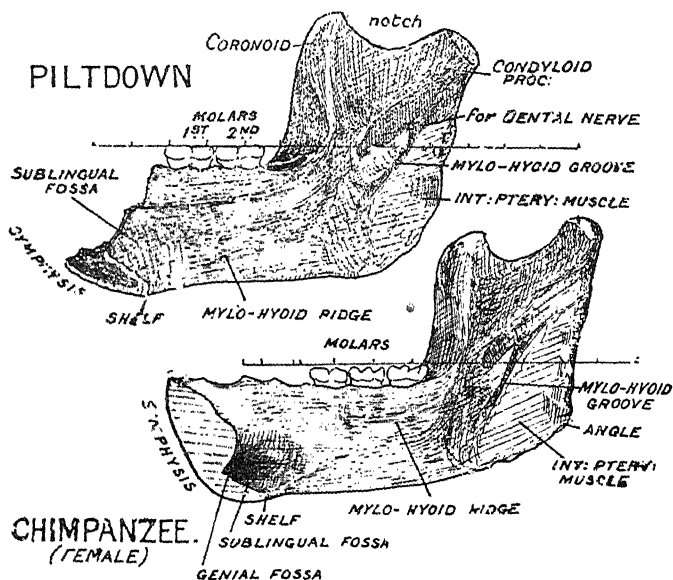
FIG. 235.—Inner aspect of the right half of the Piltdown mandible contrasted with the corresponding view of the right half of the mandible of a young adult female chimpanzee.

ment seen in anthropoids. It is possible that the surface of this fossil bone has been rubbed and smoothed somewhat as it lay in the gravel bed of the ancient Sussex stream, but there is no evidence of any marked erosion on the inner aspect of the mandible. We must therefore conclude that the individual of which this mandible formed a part had the mouth and tongue movements of an anthropoid ape. And yet we have seen that the brain which lay within the skull was human in size and form. In his address as President of the Anthropological Section

of the British Association at Dundee in 1912, Professor Elliot Smith anticipated that such a combination of parts might occur. He rightly foresaw that before the anthropoid characters would disappear from the body of primal man, the brain, the master organ of the human body, must first have come into its human estate. Under its dominion the parts of the body such as the mouth and hands, the particular servants of the brain, became adapted for higher uses. Looking at the problem from this point of view, we cannot reject the Piltdown mandible because as regards the mylo-hyoid ridge it is simian and not human in character.

We pass on to the consideration of another character —one to which Sir A. Smith Woodward was at first inclined to attach a considerable degree of importance. On the inner aspect of the ascending branch or ramus of the mandible—the part to which the muscles of mastication are yoked—the opening for the nerve and vessels, which enter the jaw to nourish the teeth, is seen (fig. 234). Its anterior sharp margin carries a projecting spine. At its hinder lower margin runs off a narrow groove in which lie the vessels and nerve for the supply of the mylo-hyoid muscle. The groove is known, therefore, as the mylo-hyoid groove. Both vessels and nerve come from the main structures which enter the jaw at the dental foramen. The vascular groove is often separated from the one for the nerve. If the inner aspect of the chimpanzee's jaw is examined (fig. 235) the dental opening is readily seen ; it is large, but there is no short spine on its anterior border and the mylo-hyoid groove takes its departure some distance behind the opening for the dental nerve. Exactly the same characters are seen in the Piltdown jaw ; in this respect, also, the mandible is simian. When we seek to appreciate the significance of this character, we note at once that it is not the mylo-hyoid groove which has shifted away from the dental opening. In the human jaw the dental opening lies 20 mm. or more behind the last molar tooth ; in the Piltdown jaw and in the chimpanzee's the distance

is considerably less—only 15 mm. It is easy to see how the difference has arisen. During the years of youth, when the milk teeth are being replaced and space is being provided for the accommodation of the three permanent molars, the ascending ramus of the jaw is undergoing a process of continuous reconstruction. The nature of the change can be realised from the mandible of the infant gorilla shown in fig. 234. The two milk molars are in place. In the course of time, space for three large permanent molars—a space of 45 mm. (1·8 inches)—has to be established behind the last milk molar for the three permanent molars. To secure such space, new bone is laid down along the posterior border of the ascending ramus; the anterior border is at the same time being demolished. Every year the ascending ramus is moved backwards a space; those masons of the animal skeleton —the osteoblasts—carry out the transformation. It will be seen that the opening for the dental nerve has also to be carried backwards. For some reason which we understand only imperfectly at present, the migration of the dental opening is retarded in anthropoid jaws, but the mylo-hyoid groove is not. Hence in adult anthropoids the dental opening and the mylo-hyoid groove usually become separated as in the Piltdown mandible.

Here, then, is a simian feature, but it is one on which we must not lay too much stress. It is a remarkable circumstance that in very young anthropoids, especially in the gorilla (see fig. 234), the human form of mylo-hyoid groove is present. Amongst the gibbons, which are the most primitive forms of anthropoid apes, both the human and anthropoid arrangements of this groove are found. In monkeys the human form is the rule. In this character, as in so many others already cited, man has retained throughout life a feature which is present only during the fœtal life of the ape. It will also be noted (fig. 234) that the ridge for the mylo-hyoid muscle is more clearly indicated in young than in adult anthropoids.

In a former chapter (p. 522) attention has been drawn to the most outstanding of all the characters of the

Piltdown mandible—the shelf or ledge of bone which unites the right and left halves in the region of the symphysis and chin (fig. 235). This feature has never before been seen in a human lower jaw : it is a characteristic of the anthropoid mandible. The mylo-hyoid ridge ends near the lateral border of this *simian shelf*.

We now come to a feature which is rather peculiar to the Piltdown mandible. On the inner side of the jaw, above the " simian " shelf and above the anterior indication of the myloid ridge, is a wide, shallow fossa (see fig. 235). I do not think there can be any doubt as to the nature of this fossa ; it is the impress of the salivary gland—the sublingual—which lies in the front part of the floor of the mouth above the mylo-hyoid muscle. In modern human jaws the impression of the sublingual gland is usually well marked, but variable in size (fig. 234). I have not seen any modern mandible in which the impression is so extensive as in the Piltdown mandible. The sublingual impression is not so clearly indicated in the mandibles of anthropoids as in the Piltdown specimen, although in them the gland is particularly well developed.

When the architecture of the Piltdown mandible is revealed by the use of X-rays, the arrangement of the trabeculæ and lines of bone then seen within the mandible is reminiscent of the anthropoid rather than of the human form. We know that the structural arrangement of the bony trabeculæ has a very definite significance. These minute bars or crossing lines are laid down in such a manner as to best withstand the strains and stresses to which the mandible is subjected in the course of ordinary use. If, then, the inner structure is more anthropoid than human, we must infer that the uses to which it was subjected in life were of the kind exhibited by living anthropoid rather than by living races of men. The late Professor Arthur Underwood published excellent X-ray photographs of the Piltdown mandible.[1] Although the details of architecture revealed in human mandibles by means of X-rays vary from individual to individual, yet

[1] Arthur S. Underwood, *Brit. Journ. Dent. Sc.*, 1913, p. 650.

one must admit that in its finer structure the Piltdown
mandible has more in common with the anthropoid than
with the human mandible. I will draw attention to one
feature only—the course of the canal which carries the
dental nerves and vessels. In the mandible of modern
races this canal—as revealed in an X-ray photograph—is
distinctly bent during its passage from the ascending
ramus to the body of the jaw (fig. 249, A, p. 685).
The concavity of the bend lies well below the roots of
the last molar tooth. In the anthropoid jaw the canal

N.CALEDONIAN.   CHIMPANZEE.   PILTDOWN.   HEIDELBERG.
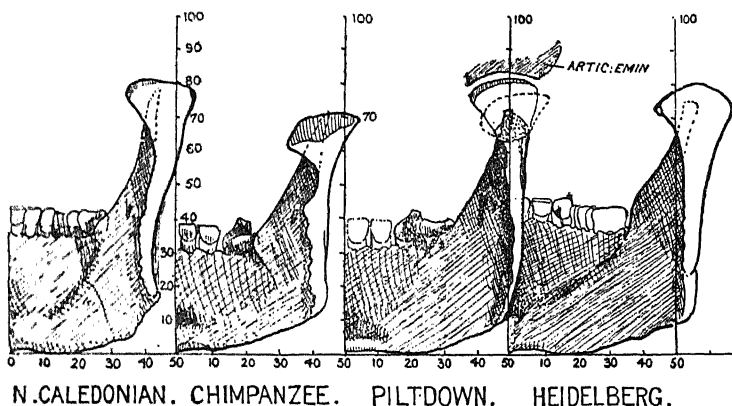
FIG. 236.—The ascending branch of a series of lower jaws, viewed
from behind.

takes an almost straight course from the ascending ramus
to the body of the jaw (fig. 248). The roots of the last
molar tooth not only reach the bend of the nerve, but
may pass beyond it. In these characters the Piltdown
jaw resembles an anthropoid jaw.

Thus it will be seen that in many of its features the
Piltdown jaw suggests that it should be linked with a
skull which is distinctly more anthropoid than the one
actually found. When we proceed to the next step—that
of actually fitting this jaw to the skull—our difficulties
become even greater. The very part of the jaw—the con-
dyle—which we most need to give us the form of contact
with the skull is broken away (fig. 236). Fortunately,

that part of the base of the skull which bears the joint
for the missing condyle is preserved on the temporal
bone.   From the size and contour of the surface of
this joint we can reckon what the size and shape of
the missing condyle must have been.   I cannot detect
any feature in the joint on the Piltdown temporal bone
which is not also represented on the temporal bones
of primitive modern races of mankind—such as the
Patagonians, native Australians, and Melanesians.   It is
true that the Piltdown articular surface differs from that
to be seen in present-day Europeans, but the difference is
the result of a change which has set in since the Neolithic
period.   We infer, then, that the condyle of the jaw
which played within the joint of the Piltdown skull was
similar in shape and size to that of modern man.   A
series of mandibles—all placed so that the chewing
surface of the molar teeth fall in a horizontal plane—is
shown in fig. 236.   They are viewed from behind, so
that the posterior edge or margin of the ascending ramus
and of the articular condyle may be seen and compared.
Side by side are placed the ascending ramus of a native
of New Caledonia and of a female chimpanzee.   The
posterior border of the human ramus widens gradually as
it passes into the condyle ; the condyle itself presents a
wide, convex surface, very little of the articular surface
actually showing on the posterior aspect.   In the chim-
panzee the posterior margin of the ramus remains narrow
until it expands suddenly in the condyle.   The condyle
shows posteriorly a considerable area of the articular
surface.   In the same series of drawings the Piltdown
and Heidelberg lower jaws are also represented (fig. 236).
The latter shows certain leanings towards the anthropoid
form in its straightness, but on the whole its characters
are human.   In the Piltdown specimen the features are
rather anthropoid.   Professor Underwood drew attention
to the manner in which the ramus of the Piltdown jaw
is compressed from side to side at the root or neck of the
condyle—exactly the form one is familiar with in the
mandible of chimpanzees.   It is therefore an articular

condyle, copied from the jaw of the chimpanzee, which one would fit on the Piltdown specimen if attention is confined to the mandible only. The shape and position of such a condyle is indicated by a stippled outline in fig. 236. A condyle so shaped will not fit the joint on the Piltdown skull—the two are incongruous. Only a condyle shaped as in human races of the modern type can be applied. Such a condyle is represented in fig. 236, with an exact tracing of the articular surface on the base of the Piltdown skull with which such a condyle moved in life. The transverse width of the condyle and joint are such as are found in modern primitive races of men —21 mm. In the drawing (fig. 236) it seems perfectly simple to add such a human condyle to the Piltdown jaw ; difficulties, however, are encountered when such a condyle is actually modelled in clay and fitted to the neck of the jaw. These difficulties, however, are not of so serious a nature as to make us actually reject the possibility of the mandible belonging to the skull ; but a certain degree of doubt is engendered.

We now come to deal with a very important feature of the Piltdown man. He has developed to the very highest degree a character which most of us who have tried to unravel the geological history of man never expected to find in an early or primitive human type. This feature is the articular eminence—a pulley-like elevation on the anterior part of the joint for the jaw on the base of the skull (fig. 237). The articular eminence is one of the most ingenious of all mechanisms to be found in the human body. It is simple and effective. The manner in which the eminence brings about the opening of the mouth in a modern man is shown in fig. 237. The stippled lines show the position of the condyle, of the coronoid process, to which the temporal muscle is attached, and of the angle of the jaw, when the mouth is closed and the food is being ground between the teeth towards the end of a chewing movement. In this phase, the condyle of the jaw has ascended within a socket—the glenoid cavity—situated on the under-surface

of the temporal bone, just in front of the ear.   If the reader will place a finger in front of the opening of the ear he will feel the condyle enter its cavity as the lower teeth close against the upper. The position of the various parts of the jaw, when the mouth is opened, is also shown in fig. 237. A rotatory movement of the ascending ramus occurs as the mouth is opened. The condyle then mounts the articular eminence. A strong
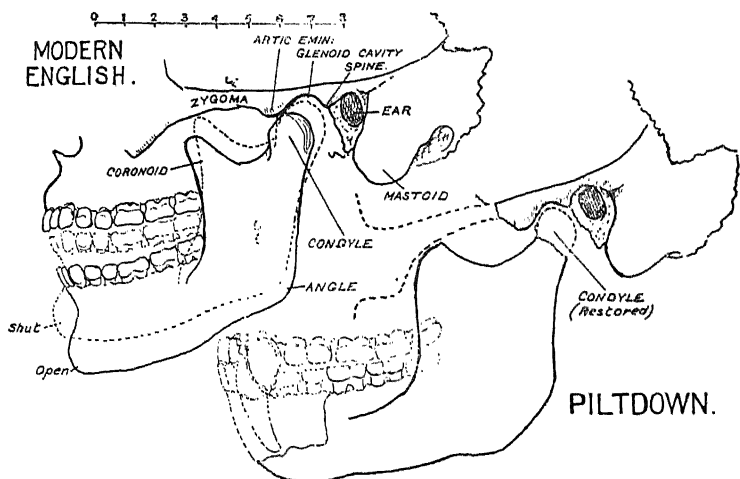
FIG. 237.—Side view of the lower jaw and mandibular joint in a modern skull. The stippled line represents the position of parts when the mouth is shut; the firm line, the open position. The corresponding parts of the Piltdown skull are also shown in the drawing.

muscle, the external pterygoid, drags the condyle forwards on the eminence, thus depressing the body of the jaw and opening the mouth. It is a general law of the animal body—one established a hundred and fifty years ago by John Hunter—that no muscle can act by itself; its opponents—the muscles which produce an opposite movement—must act at the same time to a moderate and yielding degree. The external pterygoid has three strong opponents—muscles which close the lower jaw and teeth against the upper jaw and teeth, thus masticating the food. One of these is the temporal muscle, which rises from the side of the skull and is attached to the

coronoid process (fig. 237). The two others are also important for our present purposes and must be mentioned. One is the masseter, which rises from the zygoma (fig. 237) and is attached to the outer surface of the ramus of the jaw, especially in the neighbourhood of the angle. On the deep surface of the ramus there is a counterpart to the masseter muscle—the internal pterygoid. Now, it will be seen from our illustrations that as the mouth opens under the action of the external pterygoid and the forward movement of the condyle is initiated, the coronoid process is moved forwards and downwards, elongating the temporal, while the angle moves backwards and downwards, stretching the masseter and internal pterygoids, bringing them into an advantageous position for executing a grinding movement. The part played by the articular eminence in the mechanism of opening the mouth will be evident. The resistance it offers to the forward movement of the condyle ensures a rapid opening of the mouth. It does more. When the condyle has mounted the eminence, the lower series of teeth is nearly parallel to the upper, not divergent, as would be the case if the joint movement were of the hinge type. When the three great muscles press the lower teeth against the upper, crushing the food, the condyle slips home to its socket—the glenoid cavity in front of the ear. It will be seen that, as the teeth meet and the movement comes to an end, there must be a certain degree of rubbing between the teeth, for the condyle passes backwards as it sinks home and the condyles do not come to rest exactly at the same point of time, giving the teeth a lateral movement. We expect, therefore, that the chewing surfaces of the Piltdown teeth should be worn flat, for the highly developed articular eminence and deep glenoid cavity proclaim in unmistakable terms that the chewing movements just described as true of modern man are also true of him. The chewing surface of the Piltdown molars are worn smooth and flat. This is a strong point in favour of the authenticity of the jaw.

An articular eminence of the kind just described has

until now only been seen in human races built on the modern type. We naturally regard the form of joint found in anthropoids as the more primitive—the form from which we believe the human one has been evolved. The temporo-maxillary joint of a chimpanzee is shown in fig. 238, the mandible being represented in both the opened and closed positions. A passing glance may lead

CHIMPANZEE   LA CHAPELLE
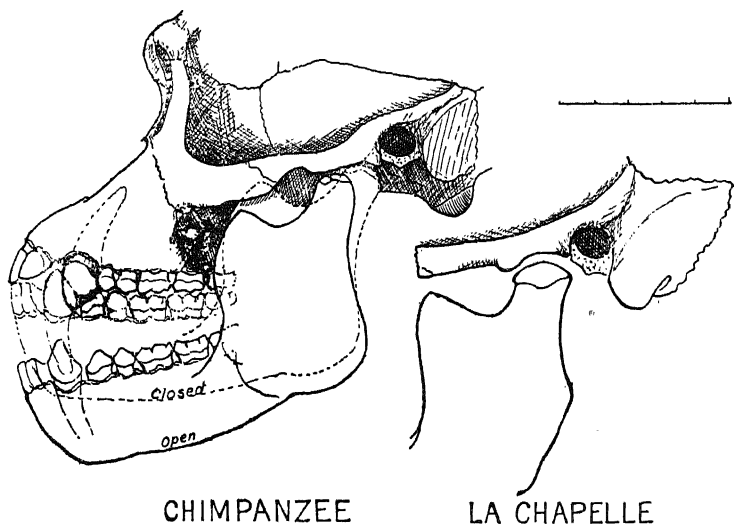
FIG. 238.—Drawing of the left half of a female chimpanzee's mandible—represented in both the opened and closed positions—to show the mechanism of the temporo-mandibular joint of a man of the Neanderthal type (La Chapelle—after Professor Boule).

the reader to the conclusion that an articular eminence is absent, but a closer examination will reveal the fact that it is not the eminence but the glenoid cavity which is missing. If figs. 237 and 238 be compared, it will be seen that in the first the floor of the glenoid cavity reaches upwards to the level of the roof of the ear passage, while the projection of the articular eminence is nearly on the level of the floor of the ear passage. In the latter (fig. 238) the articular plateau on which the condyle moves is level with the floor of the ear passage. In the chimpanzee, then, the articular eminence extends backwards to

the ear passage ; it fills up the space which should be occupied by the glenoid cavity. The peculiarity of modern man, then, is not the presence of an articular eminence, but the presence of a hollow or socket behind that eminence, into which the condyle ascends as the teeth meet.[1] Neither the articular plateau of the anthropoid nor the articular eminence of man are present in the infantile stage ; they become developed as the permanent teeth erupt (see fig. 244).

The condition of the anthropoid temporo-mandibular joint has a direct bearing on some of the problems we have now on hand. In fig. 238 is reproduced an outline drawing of this joint in La Chapelle man, whose remains have been so elaborately described by Professor Boule. This mid-Pleistocene representative of Neanderthal man was somewhat aged, but as far as the joint of his jaw is concerned he shows the typical features of his race. There is a raised articular plateau, on which the condyle moves, somewhat similar to the form found in the chimpanzee. The posterior part of the plateau is slightly depressed ; there is just a suspicion of a glenoid cavity. The bony floor of the ear passage is shaped as in the ape ; in the Piltdown skull, as also in the Rhodesian, it is fashioned exactly as in modern man.

What are the advantages of the articular plateau in the mechanism of the ape's mandible ? Both the advantages and disadvantages are shown in fig. 238. As the condyle is dragged forwards on the articular plateau, the mouth opens and the muscles of mastication are stretched. The gape thus produced differs from that seen when the human mouth is opened. The front teeth—the canines and incisors—are moved farther apart than are the hinder or the molar teeth—which are especially used in grinding. With long projecting canine teeth a wide gape in front is a necessity. Our first impulse is to regard an articular plateau as an adaptation for the long and prominent

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[1] For further details see W. Wallisch, " Das Kiefergelenk des diluvialen Menschen," *Archiv für Anat. und Physiol.*, 1913, p. 179. Lubosch, *Anat. Anz.*, 1914, vol. xlvi. p. 449.

canine teeth, but the impulse is checked when we see a very similar form of articular plateau in Neanderthal man, in whom the canine teeth are ground flush with their neighbours in the dental series. An articular plateau, then, does not necessarily indicate the presence of simian canine teeth. The particular question we have to answer, however, is this : Is a true articular eminence compatible with projecting simian canine teeth ? We know that the movements of the Piltdown mandible were determined by the contour of the joint surfaces on the temporal bone ; these are exactly similar to those of modern man. The mandibular movements must have been the same in Piltdown man as in us. Are such movements compatible with the presence of projecting canine teeth ? The solution of this problem must wait until the canine tooth found at Piltdown has been fixed in the mandible—a task which awaits us in another chapter (p. 677).

Up to this point I have passed under review the various characters of the mandible found at Piltdown to see if we could obtain any evidence which would definitely debar us from associating it with the skull. We must admit that the majority of the features enumerated are not such as we should have expected to find present in the authentic mandible ; on the other hand, there is not one which places the jaw out of court. We now proceed to review the evidence of another kind—proof presumptive in favour of the mandible and skull being parts of one individual.

We have seen that in many features the Piltdown mandible resembles that of the chimpanzee. Let us, therefore, as in fig. 239, reconstruct it as if it were such, and see the result. In comparing lower jaws, we must select a definite plane on which all are arranged, so that our comparisons may be just. The plane selected here is the upper or chewing surfaces of the three molar teeth. In fig. 239 two mandibles have been set on this plane and viewed from above. When a chimpanzee's jaw is so examined it is seen that the teeth on each side, from the third molar behind to the canine in front, form

a right and left series which are almost parallel ; the outer borders of the canine teeth are nearly as widely separated as the outer margins of the last molars. The two sides of the mandible of Eoanthropus have been given this parallel form in fig. 239, and at first we seem to have obtained a mandible of a reasonable shape with a close

(A) CHIMPANZEE.   (B) EOANTHROPUS.
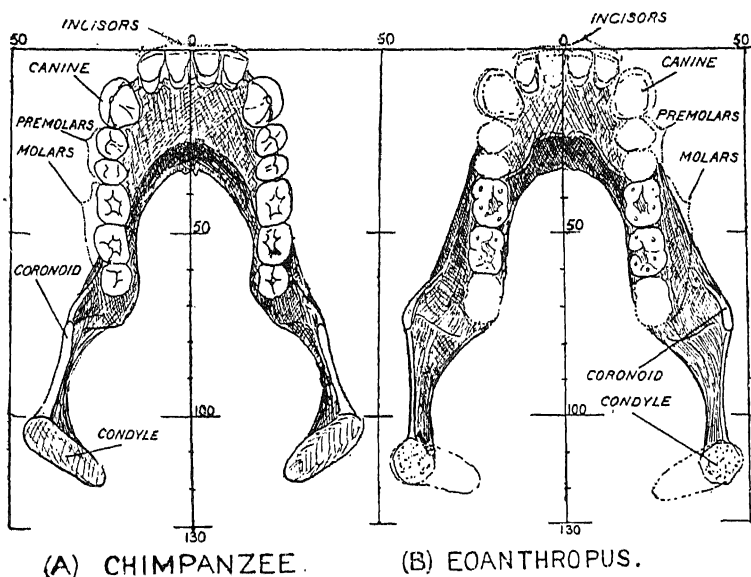
FIG. 239.—A. Lower jaw of a female chimpanzee, which has been set so that the upper surfaces of the three molar teeth are in a horizontal plane. The jaw is viewed at right angles to this plane. B. Reconstruction of the mandible of Eoanthropus on chimpanzee lines, and supplied with condyles of the chimpanzee type.

resemblance to that of an anthropoid. There is one point, however, in which this reconstruction appears to break the ordinary rules of jaw conformation—the right and left coronoid processes, to which the temporal muscles are attached, are almost as wide apart as the outer ends of the two condyles. In anthropoids, and particularly in human mandibles, the bicondylar width is greater than the bicoronoid—the measurements being made between the outer extremities of these processes. The mandible as reconstructed in fig. 239 could not be

articulated to the Piltdown skull, for the mandible attached to that skull must have had a bicondylar width of at least 120 mm., and the bicoronoid width must have been at least 100 mm. In the reconstruction shown in fig. 239 the dimensions are incompatible with the skull.

It is clear that we cannot reconstruct the Piltdown mandible on such lines and apply it to the skull. This difficulty was appreciated by Sir A. Smith Woodward in making his original reconstruction. The condyles, to fit the skull, must be placed at least 120 mm. apart. If, then, the teeth were to form parallel rows as in anthropoids, a great width must be given to the front part of the jaw. The right half of the mandible is so fractured in the region of the chin as to leave some degree of uncertainty as to whether or not the broken extremity actually reaches the middle line of the chin. Sir A. Smith Woodward took advantage of this doubt in his reconstruction and widened the region of the symphysis as in fig. 240. A mandible with distinct anthropoid characters and of very massive proportions is thus obtained. For my part, I do not think there is room for doubt ; at one point the fragment actually does reach the middle line of the chin region.

If, on the other hand, we suppose, and I think we are obliged to accept this supposition, that there is present in the right half of the Piltdown mandible a point which actually reaches and slightly crosses the middle line of the chin, then we cannot arrange the teeth in such a way as to make the two rows of teeth parallel as in anthropoids (see fig. 240). As regards the widths between the condyles and the coronoid processes, the reconstructions shown in fig. 240, A and B, agree. It may be said that both have been arranged and spaced so as to correspond to the width of the skull. To a certain extent this is true, but if an unwarrantable presumption had been made in giving such a width to the mandible, then there would have resulted an abnormal relationship between condylar and coronoid processes. On the contrary, the relations thus obtained between these processes are such as are met

with in primitive types of man.   The coronoid process must hold a definite relationship to the zygomatic arch. The bicoronoid width is less by 30 or 36 mm. than the width between the zygomatic arches in all forms of human skulls.   In Eoanthropus the bizygomatic width is between 130 and 140 mm.; the bicoronoid diameter, therefore, should be between 104 and 110 mm.   In both reconstructions it is 104 mm.   Thus, so far as regards coronoid and condylar widths, the mandible and skull are compatible.

The aspect of the lower jaw presented in the recon-
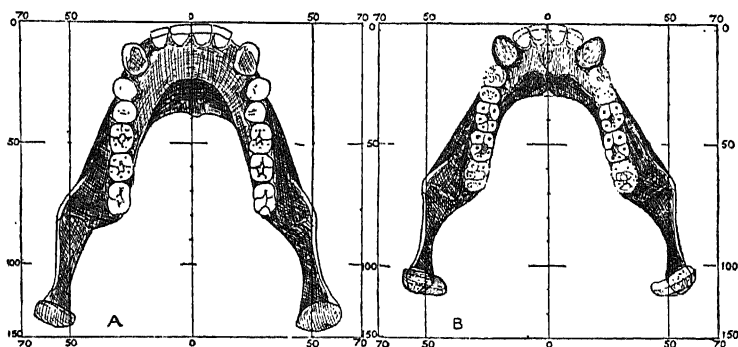
FIG. 240.—A. The original reconstruction of the mandible of Eoanthropus, viewed at right angles to the plane of the molar teeth.   B. Similar view of a reconstruction by the Author.

struction (fig. 240, A, B) gives us an opportunity of looking more closely into another of the peculiar features of Eoanthropus.   Within the semi-circle of the lower teeth lies the tongue ; the space enclosed by the inner margins of the teeth may be named the lingual area.   The larger the intradental area, the larger and more brutal the size of the tongue.   If to the lingual space which lies within the teeth we add the area represented by their chewing surfaces, we obtain a means of estimating the degree to which the function of mastication was developed.   The area we have to estimate—the counterpart of the palatal area—lies within the outer margins of the teeth, and is bounded behind by a line drawn from the hinder end of the last molar tooth on one side to the extremity of the

corresponding molar on the other side. In the original reconstruction (fig. 240, A) of the Piltdown mandible this area measured 78 mm. in length, 66 mm. at its greater width; its total extent 48·00 cm.². In the second reconstruction (fig. 240, B) the dimensions are: length 70 mm., width 64 mm.; area 39·80 cm.². Let us see how these dimensions compare with those of anthropoid apes. The masticatory area finds its highest expression in the gorilla. In the male the dimensions are: length 97 mm., greatest width 64 mm.; area 56·00 cm.². In the female chimpanzee we meet with the opposite extreme as regards the size of masticatory area. To take an average example (fig. 239, A): length 67 mm., width 54 mm.; area 31·80 cm.², which corresponds exactly to the average palatal area of the male Australian aborigine. Thus in the development of the masticatory system, Eoanthropus rises well above the lower anthropoid limit. The original reconstruction shows an area 7·20 cm.² less than the male gorilla, and 17·00 cm.² more than the female chimpanzee. With a brain developed to the amount already demonstrated for Eoanthropus, such a development of the more animal side of the body was scarcely to be expected.

It will be profitable, at this point, to see how Eoanthropus stands, in this respect, to races of men, both ancient and modern. The specimen we naturally take for our first comparison is the Heidelberg mandible; from it we can learn what the jaw development was in an ancestral form of Neanderthal man. The jaw is depicted in fig. 241, A. It has been placed and measured in the manner already described. We see that the molar teeth do not form a parallel, but a converging series. The width of the skull was evidently greater than in the one from Piltdown; the articular cavities for the jaw on the base of the skull must have been at least 10 mm. wider apart.[1] The coronoid processes have the same relative

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[1] These are the bicondylar widths of more ancient lower jaws: Heidelberg, 134 mm.; Rhodesian man, 134 mm.; La Chapelle man, 146 mm. The average width in Englishmen is 118 mm. The bicondylar width of the Piltdown mandible I estimate to have been 124 mm.

degree of separation. Indeed, as regards the hinder parts of the jaw, there is a considerable degree of resemblance in the Heidelberg and Piltdown specimens. The masticatory area of the Heidelberg mandible is large : length 60 mm., width 70 mm. ; total area 35·40 cm.²—4·40 cm.² less than in the writer's reconstruction of the Piltdown mandible, and 13·40 cm.² less than in that of Sir A. Smith Woodward.

If we examine the mandible of a modern Englishman
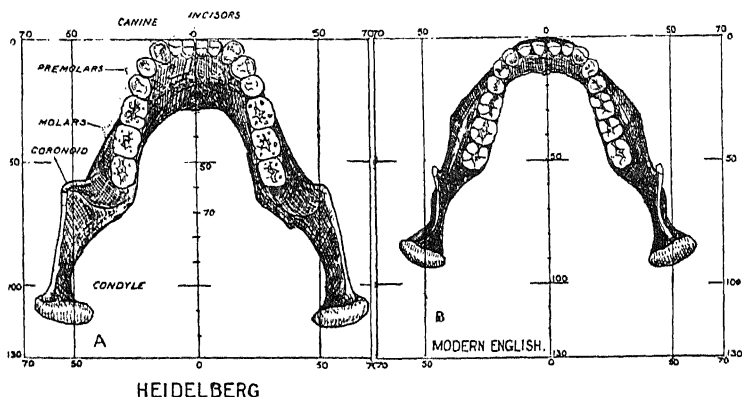
FIG. 241.—A. View from above of the Heidelberg mandible. B. Similar view of a mandible of a modern Englishman. As in other drawings, the specimens have been placed so that the chewing surfaces of the molar teeth occupy a horizontal plane.

from the same point of view the difference is very striking (fig. 241, B). The bony framework of the modern jaw has undergone a remarkable reduction. The bicondylar and bicoronoid widths have diminished, but not to a very marked extent. The masticatory area is greatly reduced. In the specimen represented in fig. 241, B, the dimensions are the following : length 51 mm., width (between outer margins of second molars) 60 mm. ; total area 24·00 cm.². If we presume that the mandible of Eoanthropus as restored by Sir A. Smith Woodward represents our ancestral condition at the beginning of the Pleistocene period, then during that period the length of the chewing area of the jaw has decreased 37 mm. (1½ inches), the width

only 4 mm., and the total area 24·00 cm.². The area has been reduced to half. It will be observed that it is in length, not in width, that the chewing area of the mandible has decreased. In the Neanderthal race, and in the Rhodesian, we may presume that the width has actually increased.

The modern English mandible represents an advanced stage in the process of reduction. For the purposes of comparison, it is better to select the mandible of a primitive race of the modern type, such as may be found amongst the extinct Tasmanians. The palate of a Tasmanian native is represented in fig. 78 (p. 214), one in which the dimensions do not fall short of those found in primitive fossil skulls. The length of the masticatory area in the corresponding Tasmanian mandible is 63 mm., the width 60 mm.; the total area 32·10 cm.², against 40·00 cm.² in the writer's reconstruction of the Piltdown mandible, and 35·40 cm.² in the Heidelberg mandible. In the mandibles of very ancient man the chewing surface exceeds the highest modern development by a considerable amount. In the course of human evolution, the chewing area has become greatly reduced, a reduction which probably followed the growing mastery of the brain. The condition in Eoanthropus suggests that the brain had reached a volume equal to that of modern man before the reduction of the jaws and teeth set in.

In the preceding paragraphs, the evidence relating to the masticatory function of the Piltdown mandible has been reviewed with the definite object of seeing whether we can reconcile its simian characters with a brain and skull which are distinctly of a human type. In the mid-Pleistocene man of La Chapelle the brain had a volume of 1620 c.c., the mandible a masticatory area which, from the reconstruction by Professor Boule, I calculate to have been 34·50 cm.². A brain volume of 1400 c.c. and a mandibular chewing area of 40·00 cm.², as in the writer's reconstruction of the Piltdown mandible, seem, when we keep the La Chapelle example in mind, quite a reasonable combination. We cannot

reject this mandible because of its anthropoid dimensions and characters.[1]

Before passing on to the next chapter, in which the evidence relating to teeth is to be considered, it will be well to draw attention to some very instructive facts brought out in the drawings shown in figs. 239, 240, and 241. So far we have centred our attention on the upper margin of the mandibular arch—the tooth-bearing margin. We must now examine the changes which have taken place at the lower margin which bounds the floor of the mouth. In the chimpanzee (fig. 239) the lower margin invades and diminishes the floor of the mouth, especially in the anterior or symphyseal region. The lower border of the symphysis lies 35 mm. behind the cutting edge of the incisor teeth, which form the anterior border of the mouth area. In the gorilla the symphysis may extend backwards 55 mm. into the floor; in Sir A. Smith Woodward's reconstruction it reaches backwards 37 mm. (fig. 240, A); in the reconstruction by the writer 30 mm. (fig. 240, B); in the Heidelberg jaw 29 mm. (fig. 241, A);

[1] The following table will help the reader in comparing the relative size of palate and brain in various kinds of man and ape. The masticatory area of the palate is from 4 to 5 per cent. greater than the masticatory area of the mandible.

	Palatal area in cm.².	Cranial capacity in cubic centimetres.	Ratio.
Gorilla (male)	65·00	518	1 : 7·9
Chimpanzee (female) . . .	36·50	320	1 : 8·7
Piltdown skull, original reconstruction	53·20	1070	1 : 20·0
,, ,, Author's reconstruction	42·00	1400	1 : 33·3
Gibraltar skull	31·60	1200	1 : 38
La Chapelle skull	39·00	1620	1 : 41·5
Rhodesian skull	41·00	1300	1 : 31·7
Talgai skull	40·00	1300	1 : 32·3
Wadjak skull, I. . . .	35·00	1550	1 : 44·3
,, ,, II. . . .	41·00	1650	1 : 40·2
Tasmanian skull . . .	36·70	1350	1 : 36·7
* Australian (aborigine) skulls .	31·60	1290	1 : 40·8
* Negro (West Coast) skulls . .	29·00	1350	1 : 44·4
* Chinese skulls	26·50	1470	1 : 55·6
* British skulls	25·00	1490	1 : 59·6
* Ancient Egyptian skulls . .	25·00	1380	1 : 55
** Skulls of natives of Punjab .	28·60	1375	1 : 48
** Bushman skulls . . .	24·70	1250	1 : 50
Child at birth (European) . .	6·50	300	1 : 46
Child of 3½ years (European) .	9·00	1050	1 : 116

* Mean measurement of ten skulls.   ** Mean measurement of five skulls.

while in the modern English mandible (fig. 241, B) the distance is only 13 mm. The widening of the aperture of the buccal floor has occurred at the sides as well as in front at the symphysis. Thus we see that in the evolution of the mandible of modern man a double change has been at work: while the teeth and the upper margin of the mandibular arch have undergone a great degree of reduction, limiting greatly the tongue space, the lower margin has really increased, giving a greater width to the floor space of the mouth. Such a change will give greater freedom to the tongue in the articulation of words. In both the Piltdown and Heidelberg jaws, especially in the former, the condition of the floor of the mouth, in shape and size, is simian or ape-like; the characteristic modern changes have not yet appeared in the mandibles of those ancient types.

Thus in our scrutiny and reconstruction of the Piltdown mandible, although we have come across many details of structure which seem to suggest that it formed part of an anthropoid rather than of a human being, we have met with no feature which clearly debars it from being placed with the skull. It was found in the same stratum and near the skull; its condition of fossilisation and the texture of its bone are the same as in the skull, and it has certain characters which appear to me to prevent us from reconstructing it purely on anthropoid lines. We can with some confidence assume we are dealing with parts of one individual; our difficulties are infinitely greater if we try to allocate the skull to a human being and the mandible to an unknown kind of anthropoid.

EVIDENCE OF THE TEETH OF FOSSIL MAN

It will be remembered that Sir A. Smith Woodward came to the conclusion, on perfectly legitimate grounds, that Eoanthropus had been provided with front teeth, not of the human, but of the anthropoid pattern. When the mandible was reconstructed the space for the front teeth was found to be so great that only teeth of the anthropoid type were sufficient to fill it. The conformation of the mandible, especially in its front part, was essentially the same as in anthropoid apes; it was therefore a natural inference that the teeth, especially the canines, were pointed and prominent and used as in apes. I came to an opposite conclusion—on the grounds enumerated in the last chapter. The joint for the mandible on the skull is similar in all respects to the joint of men of the modern type; I could not see that such a joint was compatible with prominent canines. The molar teeth were worn flat and smooth exactly as in primitive modern races. The temporal muscles of mastication were not larger than in modern man. The front space of the reconstructed mandible could be filled by teeth which were modern in form but of large dimensions. There can also be no doubt that the size of brain influenced me; I did not expect to find a brain which was so eminently human combined with a tooth which was so distinctively simian.

It is instructive to reproduce the reconstruction of the Piltdown teeth and mandible which were made before the canine tooth was actually found (fig. 242). On these early reconstructions are superimposed drawings of the teeth and mandible of a modern Englishman. It will be seen

that in both reconstructions the Piltdown teeth project in
front of and also behind the teeth of the modern man.
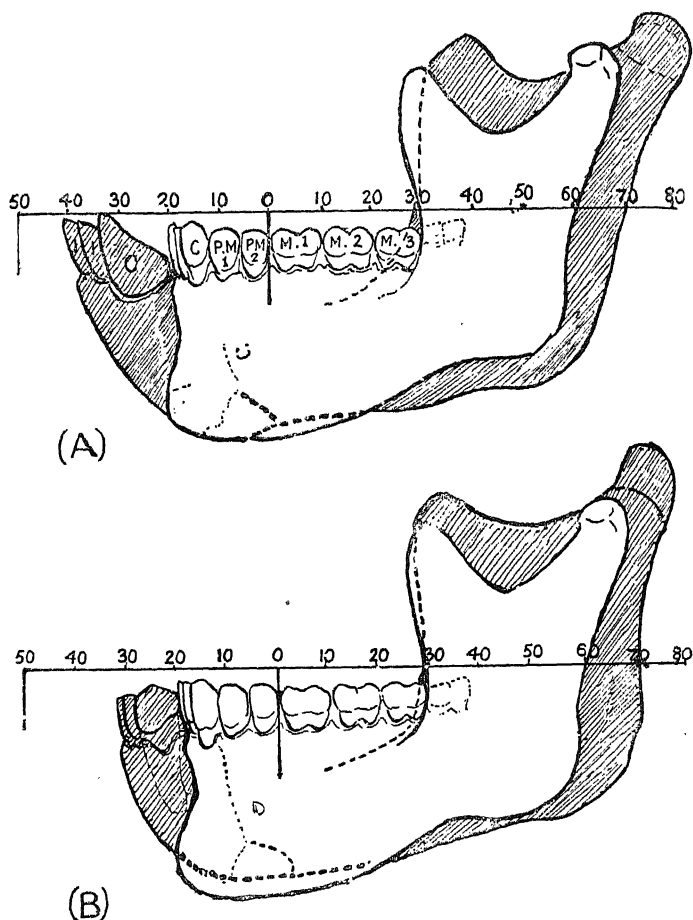
FIG. 242.—A. True profile drawing of the model of the Piltdown mandible
   and teeth reconstructed under the direction of Sir A. Smith Wood-
   ward.   Placed on it is the mandible of a modern Englishman.   The
   first molar tooth of the one is placed over the first molar tooth of
   the other.   B. A reconstruction by the writer.   The same modern
   mandible is used for comparison.

The total dental length, as seen when the face is turned
in true profile, is 50 mm. in the modern Englishman,
78 mm. in Sir A. Smith Woodward's reconstruction, and

70 mm. in the drawing shown in fig. 242, B. The difference in the canine tooth is also apparent. It is conical and pointed, with a back-to-front diameter of 14·5 mm., in fig. 242, A; it is blunt as in modern man, with a front-to-back diameter of 10 mm., in fig. 242, B. The drawings also bring out another feature to which reference will have to be made. It will be observed, in the scale placed above the teeth (fig. 242), that the zero of the dental scale is placed between the second premolar and the first molar tooth. Behind the zero point lie the three molar teeth, concerned in grinding and pulverising the food; in front of this point are the cutting teeth, five in number—two premolars, one canine, two incisors—concerned in biting and in the initial breaking up of the food. The zero point is thus situated at the junction of two functional areas—the front and back—and lies in the most stationary or conservative part of the dental series of the group of animals to which man and the higher apes belong. If the molar teeth in the higher primates undergo a change, it is the last or third of the series which is first affected. In the actual reduction or increase of the front teeth, the canine is the centre of the change, but the movement of the teeth, if reduction takes place, is towards our zero point. As will be seen from fig. 242, A and B, there is no difference of opinion as regards the Piltdown mandible and teeth behind the zero point; the difference concerns the parts which lie in front of the zero point. Whether we regard Eoanthropus as a direct ancestor of modern man, or a collateral stem which became extinct, we must suppose that the mandible represents a primitive human form, and that it is from such a form that our modern mandibles have been evolved. The changes required to convert a Piltdown mandible into one of the modern European type are represented diagrammatically in fig. 242, A and B. In front of the zero line there has been a reduction of over half an inch. Behind the zero point the degree of reduction has been much less—only 7 or 8 mm. in the length of the molar teeth, and 10 mm. in the

width of the ascending ramus of the jaw. If the reduction depicted above represents changes which have occurred in the human mandible and teeth since the beginning of the Pleistocene period, then we must infer that the structural evolution of man has taken place at a surprisingly rapid pace.

As already said, the reconstructions of the mandible shown in fig. 242 were made before the actual discovery of the canine tooth. A situation with a certain degree of piquancy thus arose, for we were all well aware that Mr Charles Dawson was busily extending his researches at Piltdown, and that any day a discovery might be made which would settle finally which reconstruction was right and which was wrong. Early in August 1913, Father P. Teilhard de Chardin, who shared in all the toils at Piltdown, discovered first the two nasal bones—the bones which form the bridge of the nose—and secondly a canine tooth, all in the same " dark " Eoanthropic stratum and near the original site of discovery. Like all the fragments of the skull the nasal bones were human in character ; like the majority of the features of the mandible the canine tooth was of the anthropoid type. Sir A. Smith Woodward's reasoning led him in the right direction ; mine led me in the wrong.[1]

Accurate drawings of the tooth thus discovered are represented in fig. 243. The middle of the upper series in this drawing shows the side of the tooth which is directed towards the tongue, for it is the lower canine of the right side.[2] It was also the right half of the

[1] See " Supplementary Note on the Discovery of a Palæolithic Human Skull and Mandible at Piltdown, Sussex," by Charles Dawson, Arthur Smith Woodward, and Grafton Elliot Smith, *Quart. Journ. Geol. Soc.*, 1914, vol. lxx. p. 82.

[2] After a minute study of the Piltdown canine, Mr Leon Williams came to the conclusion that it is an upper, not a lower tooth. This opinion has also been formed by several who afterwards made a study of this canine, including Mr Gerrit Miller. Readers who wish to consult a standard treatise on the teeth of men and apes, with a full summary of all that is known of their evolution, should consult Dr W. K. Gregory's *Origin and Evolution of the Human Dentition*, Baltimore, 1922.

mandible which was found. For comparison the right
lower canine teeth of a young female chimpanzee (1), of
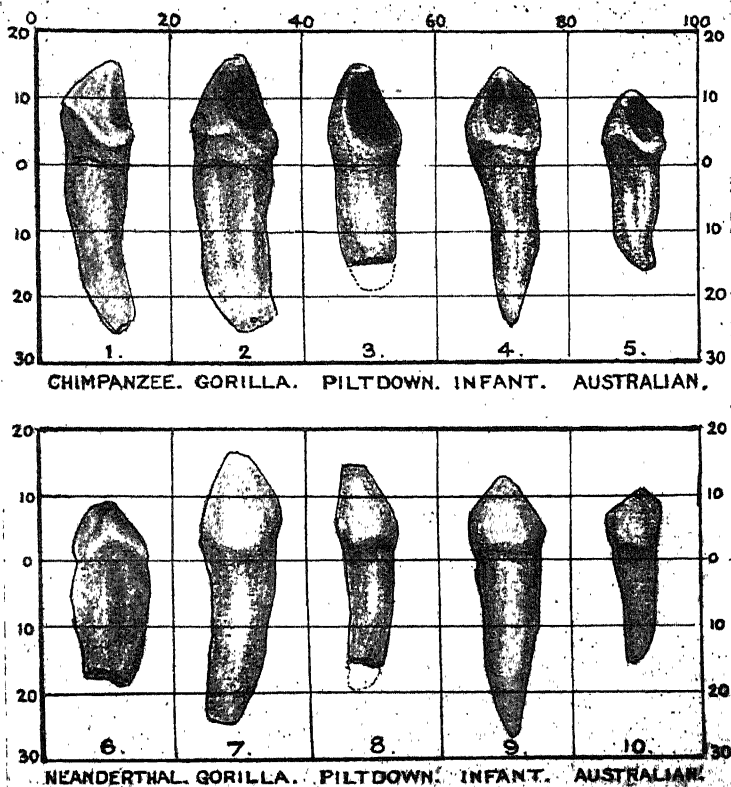
FIG. 243.—The right lower canine tooth found at Piltdown compared with
the corresponding tooth of man and of anthropoids.

  1. Right lower canine of a young female chimpanzee (lingual aspect).

2.	,,	,,	,, a female gorilla	,,
3.	,,	,,	,, Eoanthropus	,,
4.	,,	,,	,, a child (twice nat. size)	,,
5.	,,	,,	,, an Australian native	,,
6. Left	,,	,,	Neanderthal man	,,
7. Right	,,	,,	a female gorilla	(anterior aspect).
8.	,,	,,	,, Eoanthropus	,,
9.	,,	,,	,, an infant	,,
10.	,,	,,	,, an Australian native	,,

a female gorilla (2), of a child in the " milk " stage of
dentition (represented twice natural size), and of an

Australian native, are placed in series with the Piltdown specimen. All are poised so as to show the inner or lingual aspect. In shape and size the tooth is clearly more closely related to the anthropoid than the human form. The crown is conical pointed and rises 14 mm. above the neck—the constriction surrounded by the gum. In female anthropoids, the canines being much smaller than in the males, the crowns rise from 16 to 20 mm. above the neck. In modern human races the canine crowns are never shaped as in the Piltdown specimen, and rarely rise more than 12 or 13 mm. above the level of the neck. The greatest diameter of the crown—from the outer or labial margin to the inner or lingual—is somewhat less than Sir A. Smith Woodward had postulated (14·5 mm.). It measures just under 11 mm., a dimension never reached in the canines of modern man ; in them the greatest diameter rarely exceeds 9 mm. In Neanderthal man this measurement is frequently exceeded (fig. 243), but in shape the Neanderthal canines are merely swollen forms of the modern type. The root of the Piltdown tooth is anthropoid in shape and dimensions. The exact length of the root is doubtful, the tip being broken away, but it was probably not less than 20 mm. in extent. In female anthropoids the roots are about 25 mm. long ; in modern human races they seldom exceed 18 mm. The canines of the Talgai skull are large (9·6 mm. in their medio-distal diameter, 10·3 mm. from outer side to inner side), but they are essentially human in shape. Their crowns, however, measured 14 mm. in height—the same as in the Piltdown canine tooth.

The original features of the crown or chewing surface cannot be discerned now. It is deeply hollowed by wear. On the excavated area can be seen a black circle marking the site of the exposed pulp cavity. Although the original characters of the crown have been rubbed away by use, we cannot doubt they were those seen on the unworn crowns of the canine teeth of apes and men (see fig. 243). On the lingual aspect of the chimpanzee's canine a ridge is seen to descend from the tip to the

heel of the crown, the heel being raised. The ridge lies between two functional surfaces. The anterior surface plies against the upper lateral incisor, and may therefore be named the " incisor " area. The hinder surface is opposed to the inner or lingual surface of the corresponding upper canine tooth ; the two surfaces represent the opposite blades of the canine shears. In the canine of the human infant (fig. 243) the same two surfaces are seen—incisor and canine. They are also apparent in the canine teeth of human adults and gorillas. The dividing ridge on the Piltdown crown has been worn away and only a deeply bevelled chewing surface is left. Which surface does it represent—incisor or canine ? I think it is incisor ; the bevelling or excavations of the crown has been caused by the upper lateral incisor. There is no mark or impress on it of the corresponding upper canine tooth. The canine of the female gorilla, represented in fig. 243, shows the kind of wear which results from the lateral incisor rubbing or biting against the lower canine, but on the lateral aspect of the crown the upper canine has worn a distinct impression. Thus in the manner in which it has become worn by use, the Piltdown canine differs from all known human and anthropoid teeth.

In the discovery at Piltdown, then, there was revealed, for the first time, a human race in which the canine teeth were pointed, projecting, and shaped as in anthropoid apes. That we should discover such a race, sooner or later, has been an article of faith in the anthropologist's creed ever since Darwin's time. In *The Descent of Man* a picture is drawn of man's immediate ancestor, one of the stipulated characters being that " the males had great canine teeth, which served them as formidable weapons." Everyone who has made a special study of human teeth —their form, growth, and eruption—has been obliged to have recourse to the theory of descent to explain the numerous facts which come under the notice of the anatomist. In fig. 244 is represented a dissection of the face of a child, aged three years, to show certain of these dental characters. In each half of the upper and lower

jaw is a set of five milk teeth—two incisors, a canine, and two molars. The crown of the first *permanent* molar, which erupts in the sixth year, is seen buried behind the second milk molar. The canines have constricted necks and sharp, conical crowns; indeed all the milk teeth are constricted at the neck—a character which can also be noted in the Piltdown teeth. When the child bites, the conical crown of the upper milk canine passes into the **V**-shaped gap between the crown of the lower canine and
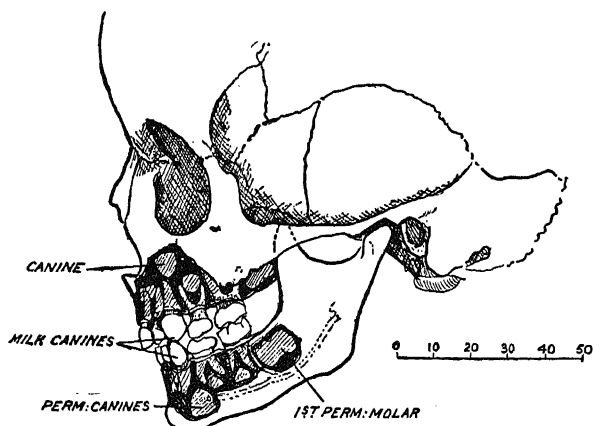
FIG. 244.—Skull of a child, dissected to show the roots of the milk teeth and the crowns of the permanent canines in process of development.

the first milk molar, rubbing against the outer surface of these two lower teeth in exactly the same manner as in an ape. There is this difference, however: while the canine of the ape wears in such a way as to maintain a sharp chisel edge, the points of the human canines become rubbed away. To explain the pointed conical form and the manner in which the human milk canine teeth come into opposition, we must suppose that they were used at one time as in anthropoids. The developmental history of the human permanent canines also requires explanation. The budding crowns of the permanent teeth are situated at the roots of the milk teeth which they are destined to replace—all except the

canine teeth.   The crown of the upper canine, as in the anthropoid, begins to form far above the other members of the series—under the roof of the orbit (fig. 244).   The lower canine appears near the lower border of the mandible.   A deep origin for the canine is a necessity in an anthropoid.   The longer the root of a tooth, the deeper in the jaw must the crown of the tooth be developed ; the tip of the root is the last part of a tooth to form, and it is formed at the spot where the crown commenced to develop.   The canine teeth of modern man have been modified to take their place in the biting series.   Their deep seat of development can be explained only by assuming that at one time they had strong and extremely long roots, as in anthropoids.   Their time of eruption, too, is peculiar.   In anthropoids these great and highly specialised teeth appear late—with the last molar in female anthropoids and after the last molar in the males.   In Eoanthropus, the canine, having retained a development which may be called anthropoid in degree, should appear late—about the time at which the third molar cuts.   It is strange that the canine tooth of Eoanthropus should be so much worn, and yet the second molar, which comes into use before the canine teeth of anthropoids, should be worn to a relatively less degree.   In modern man the date of eruption of the canines has been accelerated.   In him it appears about the twelfth year, with or before the second molar.   The canine has lost its high degree of specialisation and taken a functional place between the incisor and premolar teeth. The position of the human canine in the dental series justifies us in assuming that it should appear before and not after the premolar teeth.   We explain its late appearance by its evolutionary history.   The discovery, then, of a race of human beings with pointed simian canine teeth was not unexpected.   We did not know at what stage of man's evolution the canine teeth became transformed, nor could we guess the exact manner in which their humanisation had been brought about, until Mr Charles Dawson's discovery at Piltdown.   Notwithstanding the

many ape-like traits in the face of Rhodesian man and of Neanderthal man, their canines had already sunk to a human level.

We now wish to see what light this discovery throws on the evolution of our modern bite—the contact which the lower teeth make with the upper. In the course of quite recent centuries the manner in which the front teeth become opposed in the act of chewing has changed amongst European races and nations of European origin. In over 95 per cent. of modern English people the cutting edges of the lower incisor teeth no longer meet the edges of the upper teeth, but pass behind them. There is an " overlapping " bite. In England, during the Anglo-Saxon period, the incisor teeth met edge to edge in the majority of the inhabitants ; the overlapping bite was exceptional. The edge-to-edge incisor bite occurs in all primitive human races ; it is also the simian form. In a thousand years or less, then, a very remarkable change has appeared in the bite of English people ; the overlapping incisor bite has become the prevalent form. With the change has come a marked tendency to vaulting of the palate, to a reduction of its area, and to irregularities in the arrangement of the teeth. At first sight it seems as if a marked evolutionary change had been wrought on our teeth and jaws in the course of twenty or thirty generations. The changes in our teeth and jaws are of a functional nature ; they are comparable with certain altera-tions produced in our feet by the use of modern boots and shoes. Were we to abandon boots and walk bare-footed, as has been the habit in all primitive human races, our feet, we believe, would resume their natural form. We have every reason to suppose that the changes in our mouths are of a similar nature. If we had to return to the " hard " fare of our early ancestors we should have to use our front teeth in a different manner and restore the edge-to-edge bite.[1]

[1] More recent investigations by the Author has shaken his belief in the " temporary " nature of these structural changes in the palate. They are evident in over 25 per cent. of the present population of Britain and are

The manner in which the edge-to-edge incisor bite is produced has a very direct bearing on the problems relating to changes in man's front teeth. It will be found that there is a double mechanism at work during mastication. One of these has to do chiefly with the front teeth—the biting mechanism; the other with the back or molar teeth—the grinding mechanism. How different these mechanisms are the reader may prove by personal observation. The great temporal muscle can be felt at work on the side of the head, anywhere between the ear and lateral margin of the forehead. If ordinary chewing movements are made, those which grind the lower molar teeth against the upper and force the condyle of the lower jaw into the depth of its socket in front of the ear passage, the temporal muscle will be felt to be strongly at work; it swells and subsides at each phase of the movement. When, however, a biting movement is carried out, one in which the edges of the lower incisors are made to meet the opposing edges of the upper incisors, the temporal muscle is felt to remain passive; the muscles which carry out this movement are the two which lie in the cheek—the masseter on the outer side of the ascending ramus of the mandible, and the internal pterygoid on its deep or buried aspect. In the inhabitants of our western cities the biting mechanism has fallen into disuse. The overlapping incisor bite has appeared. The cheeks, which are high and prominent when the biting muscles—the masseter and internal pterygoid—are well developed, become reduced and sunken, giving us our narrow, hatchet-shaped faces—our oval cast of countenance.

I have cited those modern tooth changes to introduce another aspect of the Piltdown problem. It is clear, if

not universal, but become particularly manifest in certain families. The families affected live on the same foods as those in whom the palate is normally developed, from which I infer we must seek for the cause in the nature of the stock as well as in the food. See *Lectures on the Growth of the Jaws*, issued by the Dental Board of the United Kingdom, London, 1924.

we are right in differentiating the biting from the chewing mechanism, that this observation will influence us when we come to interpret the Piltdown mandible. We have already seen that the front teeth and the corresponding part of the jaw were developed to a superhuman degree; they were almost anthropoid in size and form.[1] We may further assume that the biting muscles were large in Eoanthropus. We have to determine whether the bite of Eoanthropus was similar in all respects to that of anthropoids, or represented a transitional stage between

(A) AUSTRALIAN.   (B) CHIMPANZEE.
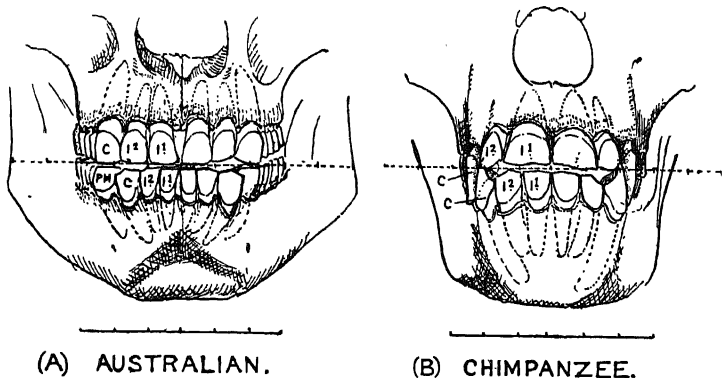
FIG. 245.—A. The form of contact between the lower and upper teeth of a native Tasmanian.   B. The form of contact in a female chimpanzee.

the primitive human and anthropoid methods of using the front teeth. This problem is set out in fig. 245. On one side is shown the manner in which the lower front teeth come into contact with the upper ones in the skull of that primitive extinct race — the Tasmanians. On the other the front bite of a female chimpanzee is shown. Our present knowledge leads us to regard the arrangement in the chimpanzee as the more primitive—the one which more nearly resembles the common type from which both forms have been evolved. The upper teeth represent the stationary blade of the dental shears, and the lower incisors—two

[1] In the Wadjak skulls, the part of the palate which carries the " front " teeth has undergone the greater degree of reduction (see p. 444).

central, two lateral—represent the moving blade. In both human and anthropoid dentitions the lower teeth come into contact with the same parts of the upper teeth. The tooth which most demands our attention is the upper lateral incisor. When an anthropoid bites, the crown of the upper lateral incisor passes into the interval between the lower lateral incisor and lower canine. It wears each of these teeth. In fig. 245, A, the crown of the upper lateral incisor comes in contact with the flattened crown of the lower canine ; in fig. 245, B, it has descended in front of the pointed crown of the lower canine. The articulation of the lower lateral incisor is also worthy of note. In both man and anthropoid the crown of this tooth forms a double contact with both upper incisors. So far as concerns the apposition of the incisor teeth, man and ape are alike. The difference relates to the canine teeth. The lower canine of the anthropoid ascends in front of and to the inner side of the upper canine, until the point of the crown reaches the interval between its two upper opponents—the lateral incisor and canine (fig. 245, B). The articulation of the upper canine is even more important. In a front view this tooth is partly hid by the lower canine. Hence its points of contact are best seen from the side (fig. 247, B). In this illustration it will be seen that when the lower jaw is closed the sharp-sided pyramidal crown of the upper canine sinks into the V-shaped interval formed by the adjacent crowns of the lower canine and first premolar teeth. A pointed upper canine necessitates a cutting margin on the first lower premolar tooth. The canines of anthropoid apes are shaped so as to serve as particularly stout shears. In man both shape and purpose are different. In him the canines serve almost the same purpose as incisor teeth. From the shape of the tooth found at Piltdown we infer that in this race the canines were anthropoid in their action as well as in their form.

A comparison of the human and anthropoid dentitions shown in fig. 245 helps us to understand how the anthropoid canines might be converted to a human form. In

the human dentition the canines, both upper and lower,
form part of the front series ; in anthropoids, although
the canines are partially seen from the front, they are
situated really in the lateral series. The transformation
of canine teeth from the anthropoid to the human form
apparently resulted from the change in their position—
during their transference from the side to the front series.
We have already seen that the evolution of modern
human races must have been attended by a great reduction
in the size of the incisor teeth and of that part of the
jaws in which these teeth are implanted. I think it is
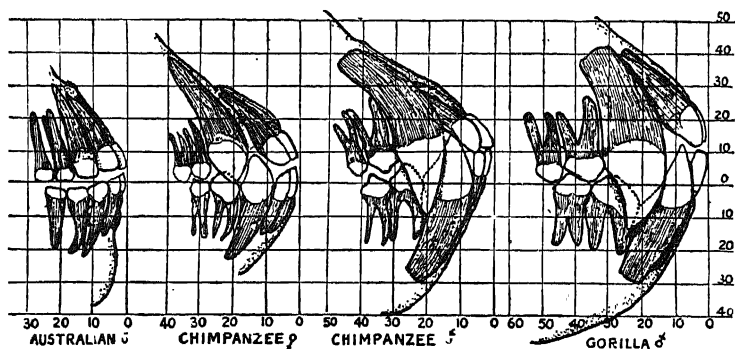
Fig. 246.—The development of the canine teeth in an Australian native,
a female chimpanzee, a male chimpanzee, and in a male gorilla.

probable, from the manner in which the Piltdown canine
is worn, that the dental and maxillary reduction had set
in, and that the canine was situated, not as in apes,
completely in the lateral series, but more in the front or
incisor series. Hence in reconstructing the lower den-
tition in the Piltdown mandible I have given the canines
an intermediate place between the side and front series
(fig. 240, B).

The discovery at Piltdown again draws attention
to the size and growth of canine teeth in the anthro-
poid apes—the animals which most closely resemble
man in structure. Four stages in the development of
canine teeth, four degrees in what may be named
“ caninism,” are shown in fig. 246—the stages seen

in man, the female chimpanzee, the male chimpanzee, and the male gorilla. There are two definite facts we may rely on. (1) That caninism varies in degree according to the kind of anthropoid. It reaches its greatest development amongst gorillas. (2) That the degree of development is influenced by sex. Amongst the great anthropoids, males have the canine teeth more developed than females. Amongst the small anthropoids—the gibbons—both sexes have long canines. Now there can be no doubt that secondary sexual characters—to a certain degree caninism is such a character—are regulated in development and growth by substances formed in the genital glands. We have evidence that the growth of canine teeth can be regulated by internal secretions or hormones. In that peculiar disease or disturbance of growth, acromegaly, which sometimes attacks men or women, the jaws and the parts of the skull concerned in mastication are particularly liable to become overgrown. The growth of the jaws is also influenced, during normal development, by secretions or substances thrown into the circulating blood by such glands as the pituitary and thyroid. A survey of the dental and maxillary development of the higher primates reveals such various degrees of caninism as are shown in fig. 246, reaching its greatest manifestation in the gorilla and the least in man. We have reason to suppose that these various forms have all been evolved from a common type, and at the present time we have the strong hope that a better knowledge of the laws which regulate the growth and development of the body will reveal to us the exact manner in which these various degrees of caninism have been produced.[1] In the stages shown in fig. 246 there is only one real break in the series—that between those represented by man and by the female chimpanzee. Does Eoanthropus serve to bridge this gap ?

We have only the lower canine to help us in answering this question, and it forms only part of the canine shears. We have seen that the first lower premolar and the

[1] See references, p. 385.

lateral incisor are also intrinsic parts of the canine
mechanism. To give a complete answer we need not
only the canine teeth but their neighbours on each side.
The condition of the lower canine can only be explained
by supposing that the canines had passed some little
way from the anthropoid towards the human condition.
We have seen that the crown of the Piltdown canine was
worn in a peculiar manner, and that its dimensions were
rather small when compared with those of anthropoid
teeth. Occasionally we do find anthropoid dentitions in
which the lower canines are worn in a manner not alto-
gether unlike the wear seen in the Piltdown specimen.
When such cases are examined it is found that the wear
is due to the upper lateral incisor, and that the lower
canines are less widely separated than is usual. I infer,
therefore, that in Eoanthropus the lower canines had
undergone an approximation, and that the partial twist
which brought them more in line with the incisors than
with the molar teeth had taken place. Their chief
opponents were not the upper canines but the upper
lateral incisors. In brief, there is an indication that the
humanisation of the canines had begun in the Piltdown
race. In the Heidelberg mandible, which Sir A. Smith
Woodward supposes to have belonged to a form of
mankind contemporary with the Piltdown race, the
humanisation of the canine teeth is complete. This fact
has an important bearing on the place we are to assign to
the Piltdown race in our ancestral tree (fig. 263).

In supplying the missing parts of the Piltdown mandible,
and the missing teeth, we must be guided, to a con-
siderable extent, by the corresponding parts of anthropoid
apes. In fig. 247 is reproduced a reconstruction of the
Piltdown mandible which differs only in detail from a
later reconstruction by Sir A. Smith Woodward. A
drawing of the mandible and teeth of a female chimpanzee
is also shown in fig. 247. The reconstruction of the
missing premolar teeth of Eoanthropus is attended by
certain difficulties. We have seen that the first lower
premolar tooth is specially modified to serve as an

opponent for the upper canine in all anthropoids (fig. 246). Was the first premolar so modified in Eoanthropus ? If the upper canine interlocked as in anthropoids, it must have been shaped as represented in fig. 252, p. 691. If

(A) EOANTHROPUS.
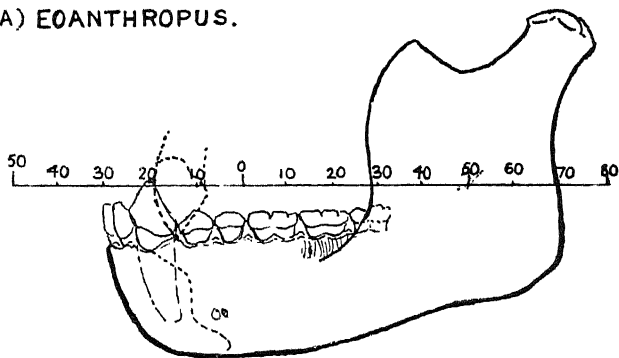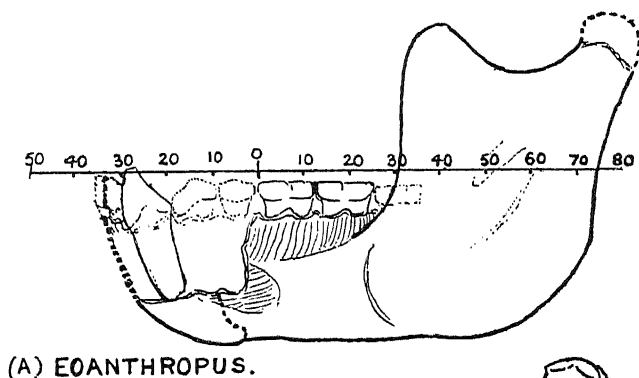
(B) CHIMPANZEE.

FIG. 247.—A. Profile of the mandible and lower teeth of Eoanthropus, as reconstructed by the writer. B. Similar view of the mandible and lower teeth of a female chimpanzee.

it did, no mark of contact is apparent on the lower canine, which is worn, as we have seen, in a peculiar manner. We have to remember, too, that the articular eminence and glenoid cavity for the articular condyle of the mandible bear witness to the fact that the chewing movements of Eoanthropus were those of modern man. What, then, was the form of the upper canine, and what was its

mode of articulation with the lower teeth ?   The solution of these difficulties must be resolved by future discoveries. In the Piltdown mandible (fig. 247, A) I have carried the cutting edges of the incisor teeth 36 mm. in front of the zero point—between the last premolar and first molar. In the original reconstruction they were placed 42 mm. in front of the zero point.   In the female chimpanzee shown in fig. 247, B, the incisors are only 30 mm. in front of this point.   In any reconstruction Eoanthropus must be given a large development of front teeth.

When we come to deal with the molar teeth we feel we are again back on safer ground.   The characters of the mandible itself, so far as they have guided us to the place which we must assign to Eoanthropus amongst the higher primates, have taken us in an anthropoid rather than in a human direction.   The molar teeth leave us in no doubt ;   they are, in the majority of their structural features, essentially human.   If the question is asked : What are the characters of these teeth which are so essentially human ?   it must be confessed that a direct and explicit answer is not easily returned.   We recognise at once the face of a friend, but we may be unable to name the number of points which enter into the act of recognition.   We become familiar with teeth—we know the appearance of the various anthropoid forms, the various human forms—and yet we find it well-nigh impossible, except at excessive length, to state the marks of identification in scientific terms.   As regards the essential humanity of the two molar teeth fixed in the Piltdown mandible there has never been any diversity of opinion amongst British anatomists.   The case of the Piltdown mandible is parallel to that of the Heidelberg jaw ;   in each case the teeth are more human in character than the framework of bone in which they are set.   The mandibular bony frame of the Heidelberg jaw is massive and bestial, but the appearance of the teeth sealed its humanity.   However we may waver over the Piltdown mandible, the clear, direct evidence of the molar teeth comes ever to our aid.   Their length dimensions alone

are not particularly remarkable when compared with the largest dentitions of primitive human races. The front-to-back diameter—the "proximo-distal" as it is technically called—of the crown of the first molar is 12·5 mm.; of the second, 13 mm. The third molar is missing, but from the indications given us by the pits for the roots we may safely infer that it was as large as the first. The total length of the molar series was thus about 38 mm. In primitive modern races the total molar length does occasionally reach 40 mm., but the average falls short of the Piltdown measurements. The molar teeth with which we may most profitably compare those of Eoanthropus are those in the Heidelberg mandible. In that specimen the first molar is 11·6 mm. in length of crown, almost the same as in Eoanthropus; the second, 12·7 mm., also the same; the third, 12·2 mm., corresponds to the estimate made for the third Piltdown molar.

When we place the teeth of modern Englishmen in comparison with the Piltdown molars we see a marked difference in their length as well as in their width. Some time ago I made a series of measurements on twenty-two English students of medicine. In them the first molar had a mean length of 10·2 mm., the second 10·1 mm., the third 9·1 mm., the total molar length being 29·4 mm.— 8·6 mm. less than in Eoanthropus. Everyone who has made extensive examinations of the tooth development of ancient races—of people who lived in the Neolithic, Bronze, or early Iron ages—is convinced that there has been a reduction in the molar development of the more highly civilised races. We do not know the exact means which has wrought this change in the human body, but we do see the order in which the teeth undergo reduction. It will be noted that in the English students the molar teeth diminish from first to third. In Eoanthropus and in the Heidelberg jaw, the reduction does not come in that order—almost the opposite. The second is larger than the first; the third is as long, or even longer than the first. If we examine the molar teeth of such primates as the gorilla and baboon, in which the teeth

reach the zenith of dental development, the order is exactly the reverse of that found in modern highly civilised races. The lower molars increase in size from first to third. It will be remembered that we fixed the zero point in the dental series between the last premolar tooth and first molar. Increase or reduction commences in the teeth farthest removed from the zero point. In the molar series the third or last is the one to show the initial change, whether it be retrogressive or progressive in nature.

The anatomists of a former generation were inclined to rely on the relative development of the molar teeth as a guide to the affinity of animal forms. There can be no doubt as to the close structural relation between the gorilla and chimpanzee, yet as regards the degree of molar development they represent opposite conditions. In the average gorilla the third molar is the largest of the series ; in the average chimpanzee it is the smallest. In one there is a progressive molar development ; in the other there is a retrograde one. If we recognise a state in which the two last molars of the lower jaw are of about the same size, as the normal or " plenal " condition, then we may distinguish those dentitions in which the third molar is the largest of the series, exemplified by the gorilla, as " supra-plenal " ;[1] the condition in the chimpanzee and modern man as " sub-plenal." As regards molar development Eoanthropus must be placed in the plenal group— perhaps in the supra-plenal.

When the chewing surfaces of the molar teeth of Eoanthropus are examined, it is seen that five cusps are clearly marked on each—two outer, two inner, and a fifth which is situated on the hinder border, near the junction of that border with the outer (fig. 240, B, p. 655). The molar teeth of Eoanthropus were thus provided with the normal complement of cusps. It is the fifth cusp which is of chief interest. In the dentitions I have described as supra-plenal, as seen in the gorilla, the fifth

[1] See A. Keith, " Problems relating to the Teeth of the Earlier Forms of Prehistoric Man," *Proc. Roy. Soc. of Med.*, 1913, vol. vi. p. 103.

cusp reaches a higher development in the third molar than in the first ; in plenal dentitions the fifth cusp is larger on the crown of the first than of the third molar ; in the sub-plenal form the fifth cusp disappears from the last molar and becomes reduced or disappears from the second also. Indeed, it is not uncommon to see modern dentitions in which the fifth cusp has disappeared from all the lower molar teeth. In the Heidelberg teeth the fifth cusp is present on the crowns of all the molars. In Eoanthropus we do not know what the condition was on the third molar, but we can see that the fifth cusp of the second molar, although not quite so large as in the first, is still well developed, and we may infer that it was present in the third of the series.[1] We have thus evidence that the molar teeth reached a plenal development at least— a degree which I have not observed in any modern human dentition.

A plenal development of the molar teeth must be regarded as a primitive feature. So, too, is the relative narrowness of the Piltdown molars. The length or proximo-distal diameter of the crowns is greater than their width—the measurement made between the cheek and tongue margins. The width of the first molar is 11 mm. ; in the second, 11·5 mm. In the gorilla and chimpanzee the length of the molar crowns is greater than the width ; in modern human races the width is equal to or greater than the length, although individual exceptions are not rare. In the Heidelberg molars the length slightly exceeds the width. Still, the narrowness of the Piltdown molars reminds us we are dealing with human teeth of a primitive form.

This feature—the narrowness of the Piltdown teeth— has been very fully discussed by Professor Ramström,[2] and by Dr Aleš Hrdlička.[3] The width of the lower

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[1] See footnote, p. 682.

[2] Professor Ramström (see reference on p. 637) regards the teeth as those of an anthropoid. See also Dr W. K. Gregory's treatise (reference given on p. 664 of this work).

[3] Dr Aleš Hrdlička, *American Anthropologist*, 1923, vol. vi. p. 195. Dr Hrdlička assigns the teeth and jaw to " a very early type of man or to his very near precursor."

molar teeth of chimpanzees, Professor Ramström observed, is never more than 75 per cent. of their length, whereas in human races, both living and extinct, the width of the first and second lower molars is 90 per cent. or more of their long diameter. In his original communication, Sir A. Smith Woodward gave the dimensions of the first molar as—length, 11·5 mm.; width, 9·5 mm.; in a later communication [1] these measurements were amended—length, 12·5 mm.; width, 11 mm. In the first estimate the width is 82·6 per cent. of the length; in the second (the right one), 88 per cent. Thus, in the relation of breadth to length, the crowns of the lower Piltdown molar teeth occupy a position between anthropoid and human teeth. This feature does not prove that the Piltdown jaw is that of an ape; it is simply an addition to the long list of characters which show to us that this ancient type of man retained many ape-like traits in the construction of his teeth, jaws, and face. In other primitive human races the teeth have expanded in width. The upper molars of Rhodesian man and of Wadjak man measure 13·5 mm. across; in Pithecanthropus the upper molars were over 14 mm. wide.

Of late years a study of the pulp cavities of the teeth, of their roots, and of the manner in which the teeth are implanted in the jaws, has thrown quite a new light on some of the problems which relate to the origin of man. The introduction of X-rays as a means of transillumination has made it possible for us to examine the buried parts of the teeth without destroying the mandibles in which they are implanted. It was the study of the pulp cavities and roots of the teeth of Neanderthal man which permitted Dr Adloff [2] to produce convincing evidence

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[1] *Quart. Journ. Geol. Soc.*, 1917, vol. lxxiii. p. 7. In this communication the diameters assigned to M¹ are—length, 12·5 mm.; width (labio-lingual diameter), 11 mm.; to M², 13 × 11·5 mm. The lower molar of the left side, found in 1915, measures 12 × 11·5 mm., the width being 96 per cent. of the length. An inspection of this tooth led me to form the opinion that it is not a first but a third molar.

[2] For references to Dr Adloff's publications, see *Anat. Anz.*, 1913, vol. xlv. p. 191.

that this mid-Pleistocene race could not stand in an ancestral position to modern man, but represented a terminal offshoot from our ancestral stem.

When the mandible and lower molars are examined by means of X-rays, the central cavities of the molar teeth, containing the sensitive living pulp tissue, are seen as comparatively clear spaces in the opaque bodies of the teeth (see fig. 93, p. 264). In anthropoids, such as the

GORILLA.
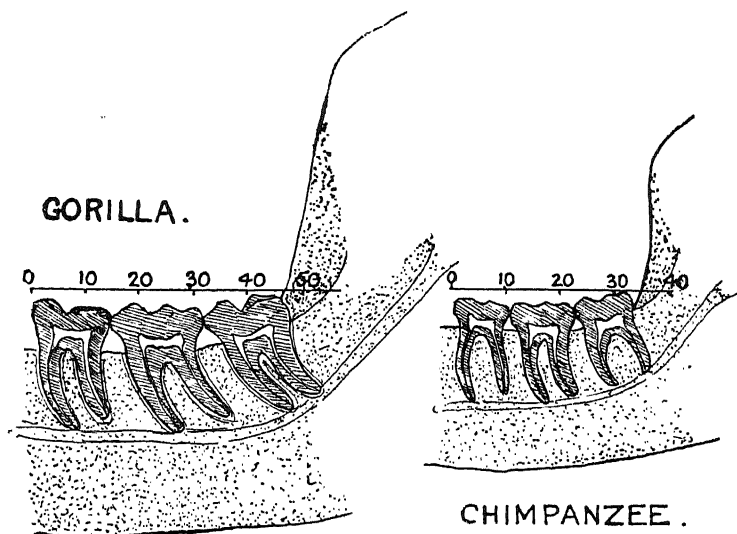
CHIMPANZEE.

FIG. 248.—Tracings from skiagrams of the lower molars of a female gorilla and of a female chimpanzee.

gorilla and chimpanzee (fig. 248), the pulp cavities are comparatively shallow spaces between the crown above and upper ends of the roots below. The cavity is situated on a level with the neck of the tooth—the junction of the crown with the body—the part formed by the fusion of the upper ends of the roots. In each of the three anthropoid molars the two roots diverge widely, especially in the chimpanzee (fig. 248). The roots of the second and third molar reach, or even pass beyond, the canal containing the dental nerve in the substance of the mandible. Two other points may be noted to

complete an imperfect picture of the anthropoid lower molars : (1) on passing from the first to the third molar the pulp cavity tends to become situated more deeply as regards the upper or alveolar border of the mandible ; (2) extensions of the pulp cavity are continued to the tips of the roots ; through the canals in the roots, vessels and nerves reach the pulp cavity.

When we compare those X-ray pictures of the lower molar teeth of anthropoids with skiagrams obtained from human mandibles certain differences become apparent (fig. 249). If, for instance, a tracing of the molar teeth of Eoanthropus, as revealed by the skiagram published by Professor Underwood, is compared first with the tracings shown in fig. 248, and then with the various tracings of human molars shown in fig. 249, we cannot have any doubt as to the group to which the Piltdown molars must be assigned. They belong to the human group ; they are remarkably like the modern teeth shown in fig. 249. The roots of the Piltdown molars are not long, only about 12 mm. ; in modern molars a root length of 15 mm. is not unfrequently seen. The roots are curved and well separated, assuming a form which may be seen in the mandibles of the more primitive races of modern man. The spread and curvature of the roots is rather less than in the chimpanzee. The third molar is unfortunately missing, but its socket is evident. The appearance of the socket of this tooth, as revealed in the skiagram, at first led me to infer that the mandible must be that of a young adult in which the third molar tooth was not fully erupted—the crown had not quite reached the chewing level. A closer examination of the actual specimen has shown that there are no good grounds for supposing that the third molar had not come into use. As in anthropoids, the roots of the last Piltdown molar reached the dental canal (compare figs. 248, 249, A, B, D). This is also the case in the Heidelberg mandible, and occasionally it also occurs in the mandibles of modern races.

Another very remarkable feature of the molar teeth of

early human races is also shown in fig. 249. In anthropoid molars we have seen that the pulp cavities, even in young adults, are comparatively small. This is also true of the pulp cavities of the molar teeth of modern human races. In the Neanderthal race there was, as we have already seen, a remarkable development of the pulp cavities,
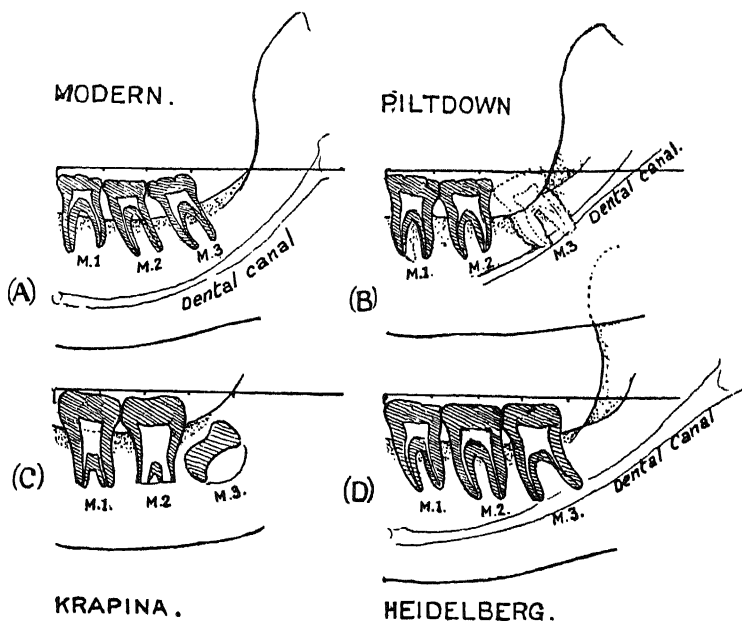
FIG. 249.—Tracings from X-ray photographs of the three lower molars of a modern European, of Eoanthropus, of a Krapina (Neanderthal) individual, and of the Heidelberg man.

particularly well shown in the specimen found by Professor G. Kramberger at Krapina, in Croatia (fig. 249, C). The pulp cavities in many of the Krapina molars almost extend to the tips of the roots. This condition is present to a greater or less degree in the teeth of all members of the Neanderthal race. It is a character of that race, although when the teeth become worn and their pulp cavities filled with secondary dentine, the condition is less easily recognised. It is equally apparent that it is not a primitive feature, for it is the

opposite to what obtains in anthropoids and primates generally. Here, then, is a very remarkable fact which throws a sidelight on the antiquity of man : by the middle of the Pleistocene period there was a race of men which showed a very aberrant and highly specialised mode of tooth development, and they had brains of great size.

The enlargement of the pulp cavities is seen to have a remarkable effect on the manner in which the teeth are implanted in the jaws. It is very clear from fig. 249, C, that the pulp cavity enlarges at the expense of the roots ; the roots of the teeth become very short, the body long and deeply implanted in the mandible. In the molar teeth of modern man the pulp cavities lie above the level of the upper or alveolar margin of the jaw ; this is also the case in anthropoids. We may regard it as the primitive condition. It is true that there is a tendency in the third molar for a downward extension of the pulp cavity to take place. We have, then, two extremes in molar formation : the condition in which the pulp cavity lies above the alveolar border, as in the molar teeth of carnivorous animals, which we may call the " cynodont " form. There is the other extreme seen in Neanderthal man, where the pulp cavity extends deeply within the substance of the jaw, recalling the molar teeth of cud-chewing animals—a form which we may call " taurodont." Now when we examine the molar teeth of Heidelberg man there can be no doubt that a considerable degree of " taurodontism " is present. The pulp cavity of the third molar is large and sinks deeply in the substance of the mandible. The other characters of that mandible show us that in the Heidelberg jaw we are dealing with a rather early and massive form of Neanderthal man. The pulp cavities of the Piltdown molars are also large, but there is no indication of a downward extension of the pulp cavity below the alveolar margin. We do not know what the condition may have been in the missing third molar tooth. We do know, however, that with the appearance of taurodontism the

body of the tooth enlarges so that the constriction or neck at the junction of body with the crown of the tooth tends to disappear. This constriction is well marked in the Piltdown molar teeth. Although the pulp cavities are large in the molar teeth of both those species of early men—Heidelberg and Piltdown—yet only in the former do we see distinct evidence of taurodontism. Nor is there any sign of taurodontism in the teeth of the Rhodesian, Wadjak, or Talgai fossils. In these races,
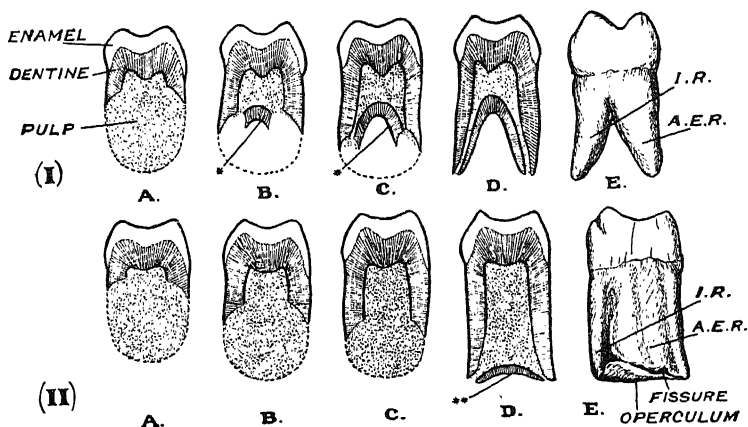
FIG. 250.—Two series of diagrams: the upper, to show stages in the growth of the second upper molar of modern man; the lower, corresponding stages in the growth or development of the same tooth in Neanderthal man.

as in Pithecanthropus and modern man, the earlier or cynodont form is retained.

If we sum up the evidence relating to the mandible and teeth of Piltdown man we must, in the first place, emphasise the remarkable mixture of human and ape-like characters which they exhibit. The mandible, as we have seen in a previous chapter, is marked by many simian traits, particularly in the region of the chin or symphysis. The articulation for the mandible, on the temporal bone of the skull, does not differ from that seen in skulls of living races of a primitive type. The molar teeth do show certain simian traits, yet are

essentially human. On the other hand, the canine tooth, in its form and size, is more ape-like than any canine ever before attributed to a human being. In shape and size it is in keeping with the mandible, but even when these admissions are made, certain difficult problems remain to be solved. One of these relates to the upper canine teeth, which must have been equally simian and pointed. The method of articulation between the upper and lower canine teeth cannot have been as in apes, because the joint for the mandible on the base of the skull shows that the tooth movements were those which take place in modern man. Whatever the exact form of articulation between the upper and lower canines may prove to be, it is certain that the discovery at Piltdown has revealed a human being in which certain anthropoid features were well marked in the teeth and jaws. It is also equally certain that the brain had passed far beyond an anthropoid stage of development. The position of the Piltdown type in man's family tree is shown in figs. 263, 266.

CHAPTER XXXV

FACIAL FEATURES OF FOSSIL MAN

THE picture we form of a human being is chiefly based on the appearance of the face. It is therefore natural that we should try to restore the facial outlines of our fossil ancestors. At the most it is only the bare skeletal outline we can rebuild ; we cannot hope to restore the living countenance. Imperfect as the picture must be, it is well worth our pains to see how far it is possible to reconstruct the face of so ancient and interesting a human form as that found at Piltdown. Fig. 252 shows the materials on which our picture has to be framed. There is, in the first place, half of the lower jaw ; the lower jaw forms a large part of the outline of the face. In the second place, there is the left corner of the forehead and left temple. In the third place, the nasal bones, which form the bridge of the nose. In the fourth, there is the root of the zygomatic process, which guides us to the width of the face and prominence of the cheeks ; and, fifthly, there is, as we have already seen (p. 502), a fragment of a frontal bone, found by Mr Dawson after the earlier reconstructions of the skull had been made. From such materials we ought to be able to build up an outline of the face, at least in its more general aspects.

Let us deal with the last-found fragment first, because it tells us about the forehead. We have already viewed it in vertical section and noted its thickness and strength (fig. 216, p. 593). In fig. 251 it has been poised on the frontal aspect of an Englishman's skull, and we note at once the two elevations which appear on its lower part,

just over the margin of the orbit or eye-socket. These two elevations or eminences, the supraciliary (a^1) and the supra-orbital (b^1), clearly correspond with the eminences on the modern forehead. They are by no means prominent on the fossil fragment, the supraciliary scarcely rising
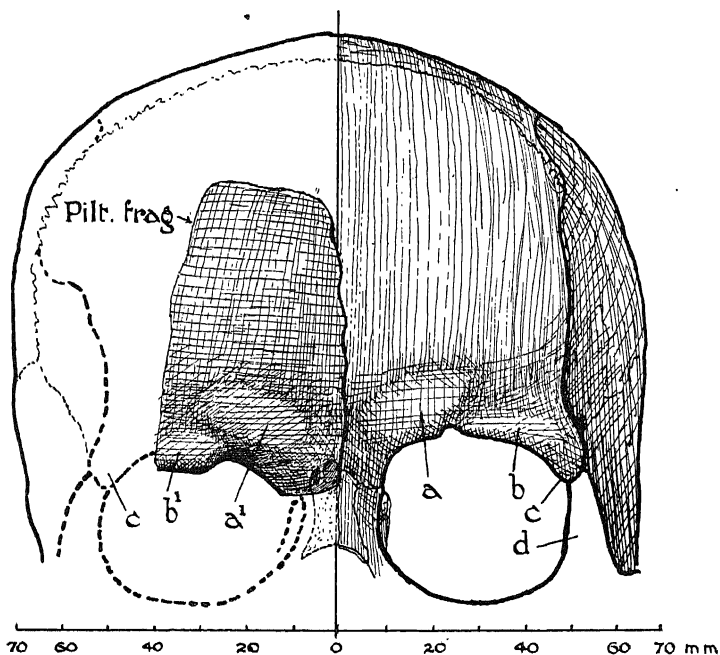
FIG. 251.—Frontal aspect of the skull of a modern Englishman. On one side, the left, details have been filled in to show its supra-orbital features (a, b); on the other side, the Piltdown fragment is depicted.

a, a^1, Supraciliary eminence. b, b^1, Supra-orbital eminence. c, c, External angular processes of English skull. d, Ascending process of cheek bone (malar).

3 mm. above the general contour of the bone; such slight development suggests a female character. Then on the orbital margin of the fragment, just where the supraciliary eminence begins to pass above the supra-orbital, we note a break or notch—the supra-orbital notch—for the passage of nerves to the forehead. It is wider and less sharply defined in the fossil than in the modern bone. From the deepest part of the notch to the inner margin

of the fragment measures 26 mm., so we may safely infer that when this Piltdown frontal bone was intact, the distance between the notches of the right and left sides was 52 mm. Now, in modern English foreheads this distance measures 49 mm. on an average ; it is more in the foreheads of negroes and Australian aborigines, where the average rises to 56 mm. and to 57 mm. It is clear,
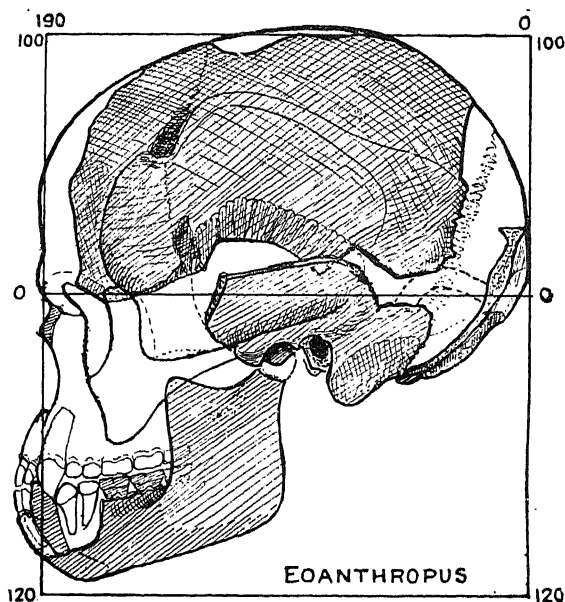
FIG. 252.—Reconstruction of the facial part of the Piltdown skull as seen in profile.

then, that as far as the middle region of the forehead is concerned, the part which enters into the formation of the root of the nose and the partition between the orbits was, in the Piltdown forehead, of moderate dimensions. There was no prominent boss of bone just above the root of the nose—at the glabella—as in Australian aborigines, nor was there a massive bony torus, as in the Rhodesian and Neanderthal foreheads. The Piltdown brow was flat and upright, and, as we shall see, of common width.

In a former chapter an account was given of an

experiment in the reconstruction of skulls. As regards
the contour of the forehead, when seen in profile, that
experiment was a failure. On the other hand, as is
shown in fig. 253, the width and height of the frontal
region were correctly reproduced. The skull thus re-
constructed, that of an Egyptian woman, had a forehead
of average human dimensions. The temporal lines, as
they ascend on each side of it, cross within the 50-mm.
vertical line, a little above the supra-orbital ridges. The
minimum width of the forehead was 98 mm. In fig.
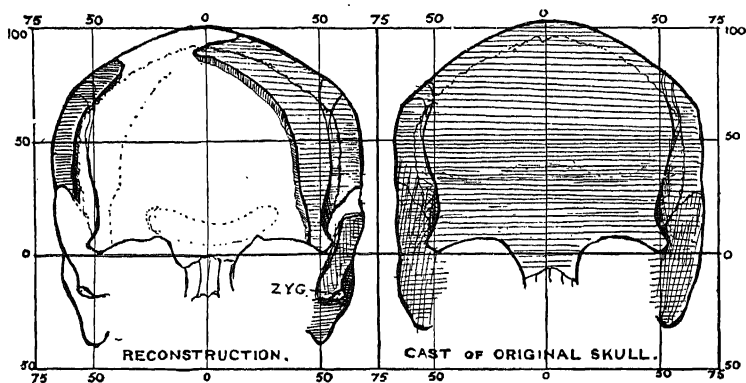
FIG. 253.—Frontal view of a reconstructed skull, compared with a cast of
the original—that of an Egyptian woman.

254 the reconstructions of the Piltdown and test skulls
are compared. In the fossil skull the temporal lines are
wider apart than in the test skull, the minimum frontal
width of the former being between 100 and 105 mm.
The forehead represents the anterior wall of the brain
chamber, and the reader may naturally infer that with
a wide forehead the frontal lobes of the brain of
Eoanthropus must also have been above the average
width. We must take into account the thickness of the
frontal bone; with a thick frontal bone, such as that of
the Piltdown skull, the temporal lines are necessarily more
widely separated than in a modern thin-walled skull.

If the frontal views of the skull reproduced in fig. 253
be examined, it will be seen that the temporal lines, as

they ascend the forehead, soon pass outside the 50-mm. lines, and at the point where they cross the coronal suture—that point being known as the " stephanion "—they lie 10 mm. outside the 50-mm. limit. The " inter-stephanic " width of the frontal bone of the test skull is thus 120 mm.—a very common measurement in modern skulls. It must also be noted that if the temporal muscles are large, their origins will be placed higher on the vault of the skull, and the temporal lines, which circumscribe their origins, will approach nearer to the
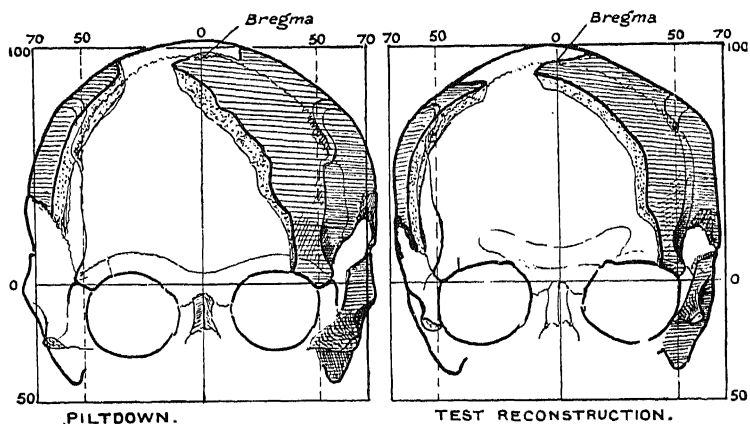
FIG. 254.—Frontal view of a reconstruction of the Piltdown skull by the Author, compared with the reconstruction of the test skull.

middle line of the vault than when the temporal muscles are small. An English skull showing a high position of the temporal lines is represented in fig. 255. In skulls of fossil men we expect to find large temporal muscles, and the temporal lines high up on the vault of the skull, so that the interstephanic diameter becomes reduced. In the reconstruction of the Piltdown skull, shown in fig. 254, the frontal bone is poised so as to represent the smallest possible frontal width ; it has been pushed inwards to a degree which somewhat interferes with the symmetry of other parts of the reconstruction. It will be seen, however, that even when the frontal region is unduly contracted, the temporal lines cross the

coronal suture 10 mm. outside the 50-mm. line. The
interstephanic diameter in the Piltdown skull is not less
than 120 mm., and the temporal lines do not ascend
farther on the vault than in the majority of modern
skulls. That is rather an unexpected fact when we
remember the size of the lower jaw and the prominence
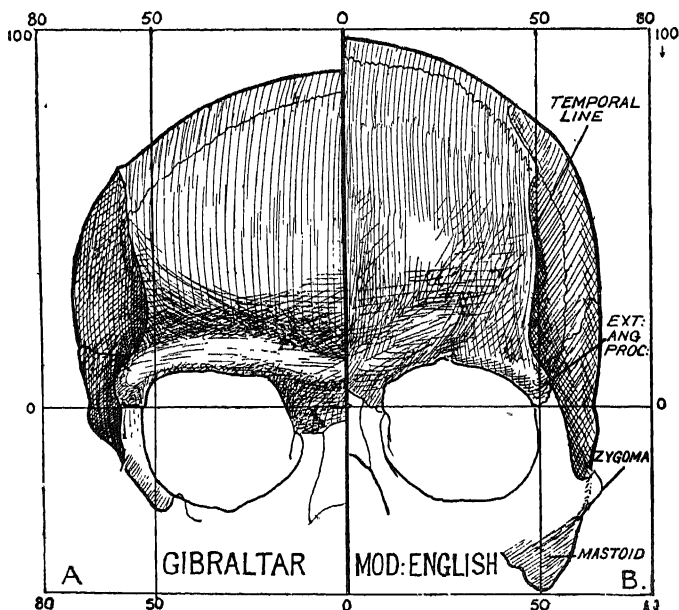
FIG. 255.—Frontal view of the right half of the Gibraltar skull and left half
of a modern English skull set side by side to show the difference
between the Neanderthal and modern types of forehead.

of the canine teeth. In the characters of the forehead
Piltdown man does not fulfil our expectation; the
forehead, instead of being narrow, low, and receding, is
wide, full, and prominent.

In fig. 255 the right half of the forehead of the
Gibraltar skull is set by the side of the opposite half
of an English skull again to recall the points of difference
between the Neanderthal and modern types. In the
Gibraltar skull the forehead is low but wide; the
temporal line ascends on the outer side of the 50-mm.

line. In the English skull, one with uncommonly large temporal muscles, these lines are situated inside the 50-mm. standard; the frontal width is under average dimensions. In this skull the frontal boss or eminence is well marked; it can scarcely be detected in the Gibraltar skull. The main point of difference between these two types lies in the conformation of the supra-orbital ridge. In the Neanderthal type this ridge forms a prominent continuous bar of bone, commencing above the root of the nose and ending externally in the angular or malar process. In the modern type of forehead, as we have just seen, the supra-orbital ridge is divided into two parts, inner and outer. As already pointed out, these ridges of the forehead form part of the bony scaffolding thrown out from the skull for the purposes of mastication. Hence in primitive races, with large jaws and strong chewing muscles, they are stoutly developed.

The outer parts of the supra-orbital ridges—the angular processes—were short and stout in the Piltdown forehead. They did not form projecting lateral knobs, such as are seen in Neanderthal skulls and in primitive specimens of modern man. In the young orang and in children we find angular processes somewhat resembling the Piltdown type. Piltdown man was evidently marked by features which differ from those of any known kind of ape or man.

Neanderthal man is characterised by the great width of the supra-orbital bar; from one angular process to the other it measures from 120 to 128 mm.; in the Rhodesian forehead this measurement reaches a " record " for man—139 mm. We expect to find a great supra-orbital width in ancient and primitive types of man, and hence it was natural that we should expect such a feature in Eoanthropus. In modelling his first reconstruction, Sir A. Smith Woodward was influenced by this belief, and also by the simian character of the lower jaw. In fig. 256 is represented the left half of his original model of Eoanthropus. The angular process projects 10 mm. beyond the 50-mm. vertical, giving a total supra-orbital width

of 120 mm. The temporal lines, as represented in this
model, have quite a different direction from that seen
on any other human skull. In fig. 256 is also shown the
right half of the forehead of one of the early invaders of
England, a round-headed type which was dominant in the
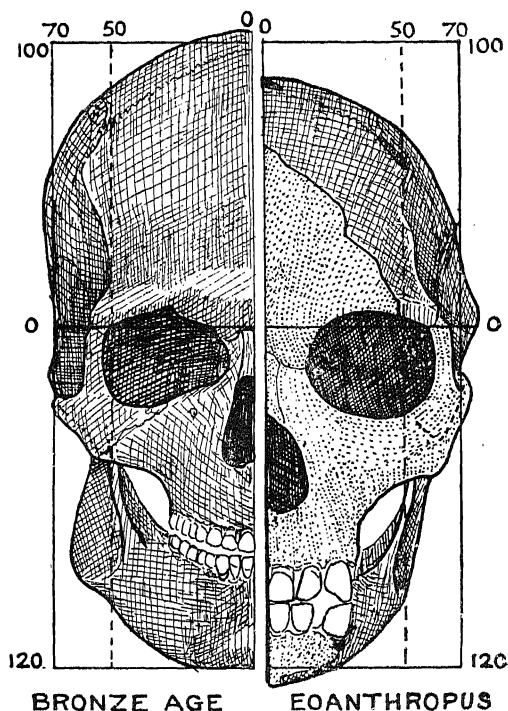
FIG. 256.—Frontal view of the left half of the original model of Eoan-
thropus contrasted with the opposite half of a Bronze-age English
skull.

Bronze age. These invaders had remarkably prominent
supra-orbital ridges and angular processes—offering a
striking contrast in this respect to Eoanthropus. The
temporal line, after leaving the angular process, draws
inwards on the forehead until it touches the 50-mm.
limit, and then begins to pass outwards as it ascends, in
the manner seen in all known types of men. If, however,
we tilt the vault of this skull downwards and inwards for

a little way, we produce exactly the same disposition of the temporal lines and of the angular process as are seen in the original model of Eoanthropus. It is highly probable, then, that the peculiar frontal features seen in the original model of Eoanthropus are reconstructional, for when we poise the frontal fragment in Eoanthropus as in all known human skulls, then, as is shown in figs. 254 and 260, the features normal to all types of men are reproduced. In my first attempts to reconstruct the Piltdown skull I also believed that the supra-orbital region of the forehead must be made wide, but this belief had to be abandoned in order that the parts belonging to the middle line of the vault might fall into their proper places.[1]

We have been discussing the characters of the forehead, which, in a strict anatomical sense, does not form part of the face but of the cranium. For the anatomist the face commences at the root of the nose and ends at the chin, thus including those parts which form the eye-sockets, the nasal cavity, and the mouth. When the anatomist measures the length of the face his upper limit is the nasion—the point of junction between nasal bones and the frontal ; his lower, the under margin of the chin. In the reconstructions of Eoanthropus, shown in figs. 256 and 257, the length of the face is represented as similar to that of modern man. The width of the face is measured between the zygomatic or cheek arches. · Now, on the left temporal bone of Eoanthropus the root of the zygomatic arch is preserved (fig. 254), and we have thus a means of judging the total width of the face. As may be seen in figs. 256 and 257, Sir A. Smith Woodward and I are agreed that in width of face Eoanthropus and modern man are not unlike. In one reconstruction the bizygomatic diameter is represented as 140 mm.; in the other

[1] In their reconstruction of the Piltdown skull, already mentioned on p. 555, Professors Elliot Smith and Hunter have given even a greater frontal than that reproduced by Sir A. Smith Woodward in his first reconstruction. In this new model the minimum width of the forehead is 116 mm., 12 mm. more than is shown in fig. 257. Such dimensions would indicate wide frontal lobes for Eoanthropus.

—the original model—as 146 mm. Another difference
between the reconstructions relates to the width of the
jowls, measured between the angles of the lower jaw. In
both reconstructions the angles of the lower jaw are set

MODERN ENGLISH   EOANTHROPUS
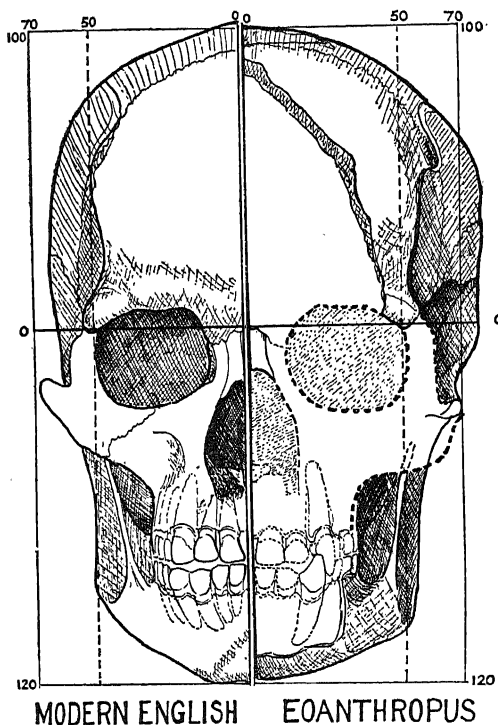
FIG. 257.—Frontal view of the right half of the forehead and face of a
modern Englishman contrasted with the left half of the Piltdown
skull, as reconstructed by the Author.

100 mm. apart, quite a common distance in modern
human faces; but in the original model (fig. 256) the
side contour of the face is that seen in apes, while in the
other (fig. 257) the human form is reproduced. The
ape-like contour is due to the fact that in the original
model the lower jaw is set at a very oblique angle.

In the nasal bones of Eoanthropus we again come
across features which are eminently human. In shape

and size they are short and thick. They resemble the nasal bones seen in negroid and in Mongolian races.[1] If merely the nasal bones had been found at Piltdown, anatomists would have agreed that an ancient representative of a negroid race, one with a resemblance to the Australian aborigine, had been discovered. If merely the canine tooth or mandible had come to light, they would have been equally convinced that they had to deal with parts of an anthropoid. If merely the skull bones had been recovered, Eoanthropus would have been regarded as purely human and given a position in the immediate ancestry of modern man.

From the nasal bones and from the size and shape of the upper canine teeth, we are assured that the nose must have been wide and flat as in negroid races. We must infer, too, from the retreating, ape-like chin, from the size of the canine and incisor teeth, that the mouth and jaws formed a projecting muzzle, more so than is the case in any known type of fossil man. In this feature he must have resembled the Talgai type and differed from the Rhodesian, Wadjak, and Neanderthal facial type wherein prognathism is masked by the forward position of the forehead. (Compare fig. 252, p. 691, with fig. 139, p. 395.)

From the cursory survey just given, the reader may have concluded that, so far as the reconstruction of the face of Eoanthropus is concerned, there is no sure foundation of fact on which the anatomist may build. This is not the case. In fig. 258 a problem in face reconstruction is presented. The skull is from a native Tasmanian with a palate only 10 mm. shorter than that of Eoanthropus. In this problem of face reconstruction we are given, in the first place, that part of the mandible which is shaded and three teeth. From these we could reconstruct the complete lower jaw with a fair degree of accuracy. In the second place, we are given all those parts of the skull which are shaded—replicas of the Piltdown fragments. The problem is to reproduce

[1] For details of measurements of nasal bones, see references on p. 664.

the parts of the face and forehead shown by stippled lines. Our first step is to complete the mandible and place its condyles in their sockets, in front of the ear passages. The second step is to complete the zygomatic arch : not a difficult procedure, for its commencement
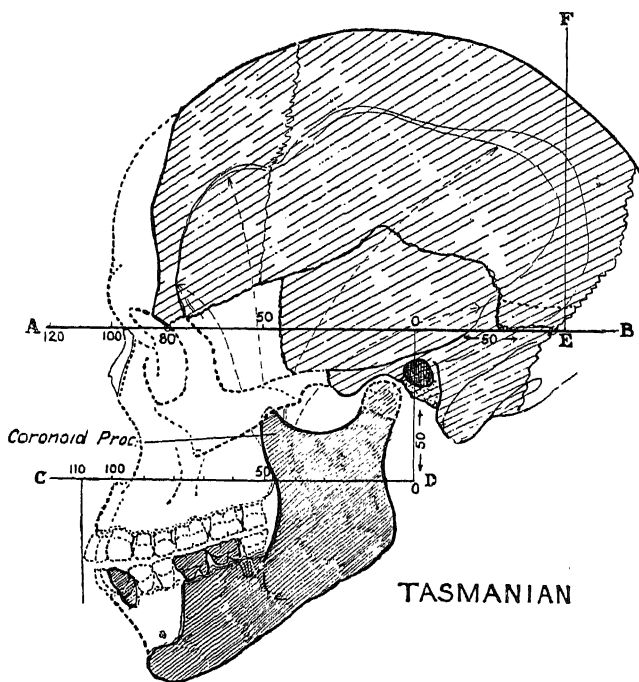
FIG. 258.—Profile of the skull of a native Tasmanian—a race now extinct. The parts stippled are those which have to be filled in from inference in reconstructing the Piltdown skull.

and direction are given us, and so is the angular process of the frontal bone, to which the arch is indirectly joined. Two other points help us : the lower border of the orbit is nearly on a line with the upper border of the zygoma, and the root of the nasal bones occupies nearly the level of the plane A–B, on which the skull is poised (fig. 258).

In our illustration it will be seen that the tip of the coronoid process of the mandible just reaches the zygomatic arch. This is the usual relationship in anthropoid

skulls and in human skulls of a primitive type. We, therefore, in estimating the length of the face of Eoanthropus, flex the mandible until the coronoid process reaches the zygomatic arch. At this angle the chin reaches its normal position and marks approximately the lower limit of the face. Having thus estimated the length of the face, it is an easy matter to reproduce the palate and upper teeth, for they hold definite relations to the lower. The lower border of the zygomatic process ends above the first molar tooth in both men and anthropoids.

As the Piltdown mandible shows many simian traits, it will be well to see how far the method just employed for the reconstruction of the profile of a human skull can be applied to that of an anthropoid. For this purpose the skull of an orang has been selected, because, as already mentioned, there are some features in the Piltdown forehead reminiscent of the conformation seen in the orang. The problem and its solution are presented in fig. 259. The parts of the skull are built up on the baseline or plane represented by A, B, in figs. 258, 259; this is the subcerebral plane which has been already described.[1] In the human skull the forehead extends forward on this plane to a point which is 100 mm. in front of the ear (see fig. 258); in the orang the forehead is rather less than 80 mm. in front of the same point. When, however, we look at the lower line (C–D, figs. 258, 259), which is drawn 50 mm. below and parallel to A–B, we see the conditions are reversed. The snout or jaws in the anthropoid face project 135 mm. in front of the ear passage, while in the primitive Tasmanian the projection is less than 110 mm. In man the forehead projects, the jaws recede; in the anthropoid the opposite is the case. There is another striking difference: the zygomatic arch is lower on the base of the skull—lies nearer to the C–D line—in the anthropoid than in the human skull. This is an anthropoid character. It is evident that if we were

[1] The various planes on which skulls are " oriented " or placed when being examined or reconstructed are described at pp. 542, 580.

given those parts of the orang's skull which correspond with the Piltdown fragments and asked to reproduce the original, we could not do otherwise than construct an outline similar to that shown in fig. 259.

Let us apply the same method to the reconstruction of the face of a Neanderthal skull, such as that found at La Chapelle (fig. 260). The forehead in this case reaches a point which is 120 mm. in front of the ear, compared
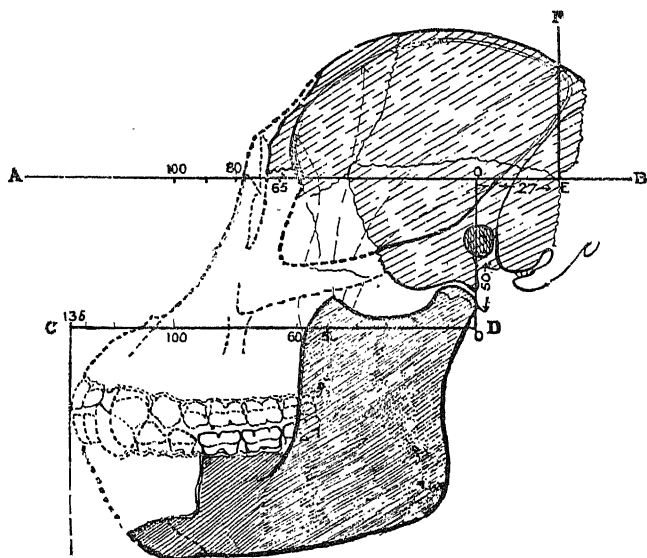
FIG. 259.—Profile of the skull of an orang. The parts which are shown by stippled lines are those missing in the Piltdown skull.

with 100 mm. in the Tasmanian and 80 mm. in the orang. When, however, the position of parts on the line C–D is examined, it is seen that the jaws project less than in the Tasmanian. The ancient extinct Neanderthal type is less prognathous—less simian, than the Tasmanian. And yet the jaws and teeth are more massive. It will be seen, too, that the zygoma is situated low down on the base of the Neanderthal skull, as in anthropoids.

By the application of this method to the Piltdown fragments we obtain results which give a reliable indication of the size and form of the face of Eoanthropus

(fig. 261). The reconstructed cranium is orientated on the plane or line A–B. We have only part of the forehead to help us, the part represented by the angular process. There cannot be any difference of opinion as to the distance of this process in front of the ear. A point
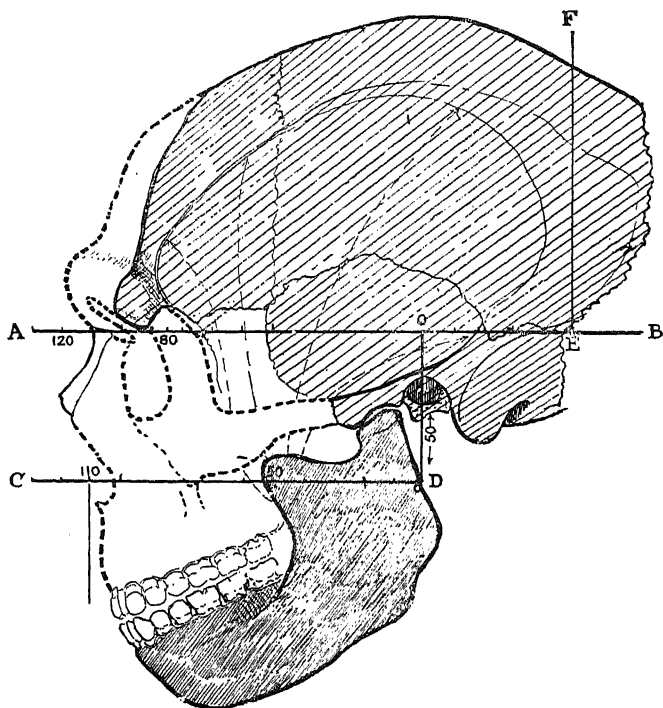
FIG. 260.—Profile of the La Chapelle-aux-Saints skull. The parts represented by stippled lines are those which have to be filled by inference in the reconstruction of the Piltdown skull.

80 mm. in front of the ear marks the centre of the process. The position of the corresponding point in the orang is 65 mm., in the Tasmanian skull 75 mm., in the Neanderthal specimen 85 mm. The angular process of the Piltdown skull thus occupies a normal human position on the plane of orientation. The total projection of the Tasmanian forehead is 100 mm., that of the La Chapelle forehead 120 mm.; we may safely assign an

intermediate amount to the Piltdown forehead—110 mm. (see fig. 261).

We now turn to the lower line (fig. 261, C–D) to ascertain how the maxillary or facial development of the Piltdown skull compares with that of the other skulls with which we are now dealing. In the Tasmanian
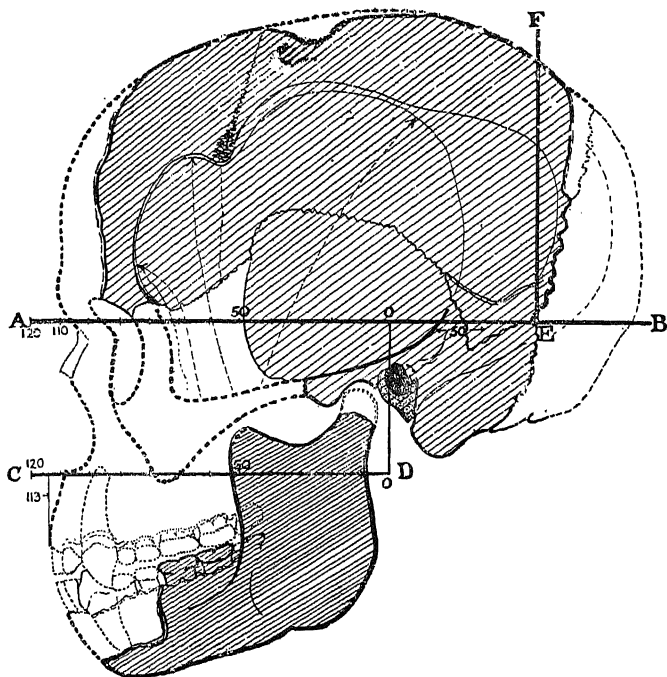
FIG. 261.—Reconstruction of the facial profile of the Piltdown skull carried out by the method described in the text.

and La Chapelle crania the "muzzle" projects almost 110 mm. in front of the ear passage. In the orang the projection is greater—135 mm. In the Piltdown specimen, in spite of the simian characters of the mandible, the facial projection is only a few millimetres more than in the Tasmanian skull. We can estimate the degree of prognathism by comparing the frontal and maxillary lines (A–B and C–D in the above figures). In the orang (fig. 259) the muzzle projects 135 mm. in front of the

ear passage, the forehead 78 mm.; the amount of prognathism—the extent to which the muzzle projects in front of the forehead—is 57 mm. In the Tasmanian the prognathism is 10 mm.; in the Piltdown skull it is not more than 5 mm. at the utmost. In the La Chapelle skull, notwithstanding the great jaws, there is really a degree of " retrognathism "—the muzzle projects about 12 mm. less than the forehead. The Rhodesian skull is also retrognathic, the projection of its forehead is 113 mm., of its jaw 90 mm.; the difference, 23 mm., represents its degree of retrognathism. Prognathism is a simian character, but it is one which was developed to only a slight extent in Eoanthropus. In spite of the pointed canine teeth and massive jaws the face of Eoanthropus was essentially human.

In fig. 261 several other features of the skull and face of Piltdown man are indicated. The zygomatic arch is situated at a lower position as regards the plane of orientation—the line A–B—than in human skulls of the modern type (fig. 258). In this respect ancient specimens of humanity resembled Neanderthal man and anthropoid apes. In the reconstruction shown in fig. 261, the tip of the coronoid process is placed on a level with the lower border of the zygomatic arch—a position occupied by this process in the other reconstructional figures. Further, the length and direction of the fibres of the temporal muscle, which are inserted on the coronoid process, are indicated by three stippled lines. The fibres of that muscle were no longer in the ancient types than in modern types of man. But as regards other muscles of mastication—the masseter and internal pterygoid—the case was different. In ancient man these muscles were very large.

In the foregoing paragraphs I have been seeking to justify my reconstruction of the head of Piltdown man. But this has not been my chief object; it has been to demonstrate that there is a science of Craniology—that skulls are machines designed on variations of a general plan, and that the exact variation can be recognised even from fragments. Craniology is to play an ever-increasing

part in the unravelling of man's early history, and we have to invent and apply exact methods.

It is for this reason that I wish to carry the Piltdown problem a step further—to apply another method which brings out still other features of this peculiar type of man. In fig. 262 a series of skulls is shown, each cut open from front to back so as to expose the parts which form the base. The series is so arranged as to bring the external meatus of the ear on the same vertical zero line. Each specimen has been set on a corresponding horizontal plane, represented by the line A–B in fig. 258.

The first point which impresses the anatomist, when he examines such a series, is that the basal axis in the orang —or in the skull of any large anthropoid ape—is as long as in the human skull, notwithstanding the fact that the human brain capacity is more than three times that of the ape. In the evolution of the higher primates the length of the basi-cranial axis or floor of the brain chamber remained nearly constant as regards length. In the orang (see fig. 262) the basal axis reaches forwards to the 40-mm. vertical line ; this is also the case in the Gibraltar and both reconstructions of the Piltdown skull. In the native Australian—a representative of the modern type —the basal axis falls 5 mm. short of the 40-mm. line. In all the types of skulls represented in fig. 262, the posterior end of the basal axis lies just behind the zero line—the line of the external auditory meatus—in all save the lowest drawing, which represents the condition of parts in Sir A. Smith Woodward's reconstruction of the Piltdown skull. There the basi-cranial axis is contracted to a degree which would seriously incommode Eoanthropus in the acts of breathing and swallowing.

The sections shown in the above series bring out another change which has occurred during the evolution of the human skull, and also one of the features of Eoanthropus. This relates to the expansion of the human cranial cavity in a backward direction as the brain assumed a greatly increased volume. The occipital wall in the orang's skull lies between 20 and 30 mm. behind the auricular

vertical line ; in the Gibraltar and Australian skulls the occipital bone reaches the 40-mm. vertical line, but in
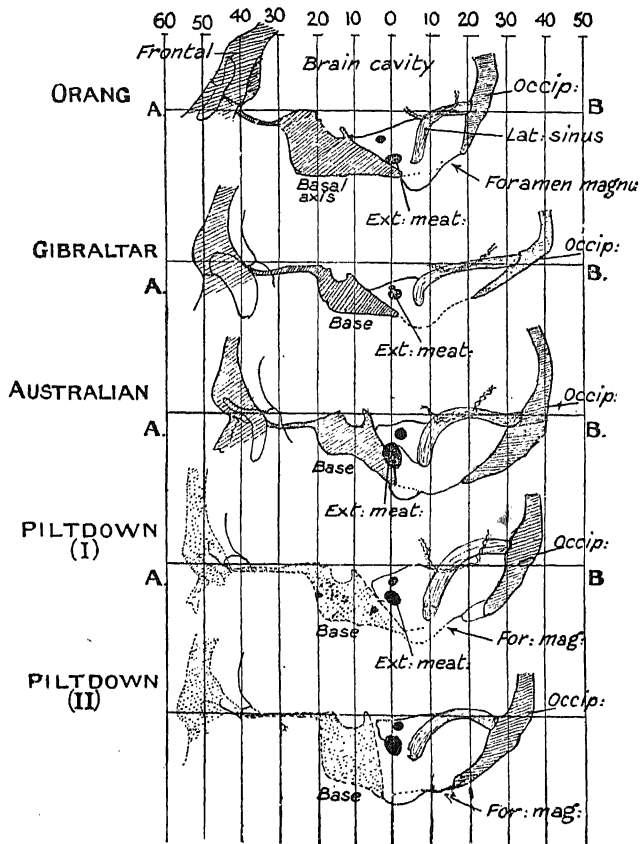
FIG. 262.—A series of skulls laid open longitudinally to show the parts forming the base or floor of the cranial cavity. Both external and internal auditory meatuses are shown : Piltdown I., from the reconstruction by the writer ; Piltdown II., from Sir A. Smith Woodward's reconstruction—further explanation in the text.

the Piltdown reconstructions it falls short of this line. In the modern type of man, as represented by the native Australian, the brain, as it expands, tends to elongate or enlarge the skull in a post-auricular direction. In Piltdown man the tendency was in an opposite direction,

to expand the skull in a pre-auricular or forward direction. Hence his high, prominent, bulging forehead. Attention is drawn to the curtailment or non-expansion of the post-auricular part of the Piltdown head in fig. 261. A vertical line (E–F) is raised from the hinder and lower angle of the parietal bone. The posterior border of this bone forms an acute angle with the vertical line, somewhat similar to the condition in the orang's skull (fig. 259). In the Tasmanian and Neanderthal skulls (figs. 258, 260) the posterior border of the parietal bone slopes upwards and backwards, forming a more open angle with the vertical line.

In this chapter we finish our survey of the structural features of Eoanthropus. Our inquiry has been prolonged and tedious, for we have had to give an account, not only of the features of this strange and ancient type of man, but to invent and to describe the methods which have to be applied if we are to place the reconstruction of skulls on a sound and scientific basis. So far as the face is concerned we can say with certainty that the forehead of Eoanthropus was well formed. It was high, prominent, and of a width equal to that of a modern human skull of average dimensions. The nasal bones were shaped exactly as in negroid races, and we infer that the nose itself must have been not unlike the broad, flat nose seen in certain primitive living races. The dimensions of the face—its length and width—did not differ from the corresponding facial measurements of other primitive forms of men. Although the front teeth—the incisors and canines—exceeded in size those of any known form of man, and although the palate must have been of very great length, yet the degree of prognathism was not beyond the limits known to occur in living races. The forward extension of the frontal region masked the great size of the jaws. But if this was the effect of the frontal projection, the receding simian formation of the chin must have given the lower part of the face a conformation not unlike that seen in anthropoid apes.

He was not in any sense a monstrous hybrid of man

and ape. His face had not the brutal, gorilline, massive size seen in Rhodesian man. He carried his body, we may be certain, as uprightly as we hold ours ; in size of brain he was as well equipped as are living native races of Africa and Australia. And yet through his structural frame there ran a simian blend—an inheritance of humanity's common ancestor. He does not merit the name given to him—Eoanthropus. He had passed far beyond the dawn of humanity. He was a partaker in the civilisation of his time—human in every essential respect, and should be spoken of as a man.

CHAPTER XXXVI

A CHAPTER OF CONCLUSIONS

THOSE of us who set out some forty years ago to search for evidence which would throw light on the antiquity of man believed we had to deal with a simple problem. We started under the conviction that there was only one kind of man—man of the modern type. We were certain that he was, like all other living things, subject to the laws of evolution, and that as we traced him, by means of fossil remains, into the remote past, we should find him assuming a more and more primitive shape and structure. The discovery of the remains of Neanderthal man in deposits of a mid-Pleistocene date confirmed us in our beliefs. With his great eyebrow ridges and his numerous simian traits, Neanderthal man was just such a being as we had pictured as our ancestor in the Pleistocene period. Then came the discovery of Pithecanthropus—an older and infinitely more primitive type of human being. He also answered to our expectations, and we adopted him as our late Pliocene or early Pleistocene ancestor. It will be thus seen that we set out prepared to find that man as we know him now was of recent origin, that in the course of a short geological period—one which is estimated at less than two or three hundred thousand years—a semi-human form of being became endowed with all the attributes of man.

Then came the discoveries of the last twenty years. Explorations at Combe Capelle and at Mentone revealed men of the modern type who, if not actually the contemporaries of Neanderthal man, were so closely his

successors in point of time that it became impossible to believe that Neanderthal man represented a stage in the evolution of modern man. Further, when we came to review critically the facts relating to the earlier discoveries made in England, France, and Italy, there grew up in many of us the conviction that men of the modern type had been in existence long before the extinction of the Neanderthal type.

With the recognition of Neanderthal man as a distinct kind or species of human being, our estimate of man's antiquity underwent a profound change. We based our conception of the ancient world of man on the picture which meets our eye when we look abroad at the present time and see a world populated by races which are but variants of one prevailing human type. With such a picture in our minds we peered into the past, expecting to find that the population of every remote geological period was made up of only one type of man. The recognition of the true nature of Neanderthal man compelled us to replace that picture with a different one—one of an ancient population made up of, not mere varieties of one species of mankind as at present, but of totally different species and genera. Amongst this complex of ancient humanity we have to seek for the ancestors of modern man. The problems of man's origin and antiquity are thus less simple than we had anticipated.

We could have avoided our initial mistake if we had kept in mind the condition of things in the anthropoid world. There, amongst the great anthropoids, we find three distinct types, two of them existing side by side in Africa (the gorilla and chimpanzee), while the third (the orang) survives in Sumatra and Borneo. They are so like to man in structure of body that we must, to account for the degree of similarity, regard all of them as collateral descendants of a common stock. We do not hesitate to think that the anthropoids retain, to a much greater degree than man, the structure, and the manner of living, of the ancient stock from which all four have been evolved. If, therefore, we try to form a picture

of the world of ancient and primitive humanity, we must base it on the conditions now existing among anthropoids, not on those which hold for the modern world of mankind. We should expect, then, when we go far enough back, to find humanity broken up into distinct structural groups or genera, each confined to a limited part of the earth. Inside each group we expect to find, as amongst the great anthropoids, a tendency to produce varieties or species. We have seen that many facts relating to ancient man which were formerly obscure or conflicting become easy of comprehension when this interpretation is applied. And all that has happened since the first edition of this book appeared has justified such a belief. Rhodesian and Boskop types have been discovered in Africa; a Wadjak type in Java; a Talgai type in Australia.

Another line of evidence ought to have raised a suspicion that we were underestimating the antiquity of man in our earlier speculations. The anthropologist, when he seeks for an explanation of the evolution and distribution of modern races of mankind, finds it necessary to make a large demand on the bank of Time. We all agree that modern human races, however different they may appear, are so alike in the essentials of structure that we must regard them as well-marked varieties of a common species. Let us look at the problem of their evolution in a concrete form, taking as opposite and contrasted types of modern humanity the fair-haired, white-skinned, round-headed European and the woolly-haired, black-skinned, long-headed negro of West Africa. We shall set those two contrasted types side by side and study them from a purely zoological point of view. We must admit that both are highly specialised types; neither represents the ancestral form. Now, in seeking for the ancestral form of our breeds of dogs, of horses, or of cattle, we select one of a generalised and ancient type, such as we conceive might have become modified into various modern breeds. We must apply the same method to the elucidation of human races. If we search the present world for the type of man who is most likely

to serve as a common ancestor for both African and European we find the nearest approach to the object of our search in the aboriginal Australian. He is an ancient and generalised type of humanity ; he is not the direct ancestor of either African or European, but he has apparently retained the characters of their common ancestor to a greater degree than any other living race. If, then, we accept the Australian native as the nearest approach to the common ancestor of modern mankind, can we form any conception of the length of time which would be required to produce the African on the one hand, and the European on the other, from the Australian type ? From what we have seen in Egypt, in Europe, and in North America it is certain that a human type can persist for many thousands of years. A human type changes very slowly. Therefore, we must make a liberal allowance of time for the mere differentiation of the modern type of man into distinct racial forms. Even if we admit that the ancestral type from which all modern races of men have descended was as highly evolved as the Australian native, I do not think that any period less than the whole length of the Pleistocene period, even if we estimate its duration at half a million of years, is more than sufficient to cover the time required for the differentiation and distribution of the modern races of mankind.

The proof that man of a modern build of body was in existence by the close of the Pliocene period is presumptive, not positive. We shall not take Galley Hill man into account at this point because his authenticity is still in dispute. If we leave his evidence out of count, then the first sure signs of the presence of the modern type of man in Europe lie in deposits belonging to the latter third of the Pleistocene period, when the Aurignacian culture replaced the Mousterian—a date which, on the scale of reckoning used in this book, takes us back only some twenty thousand years. We presume a much greater antiquity for the type than this in order to obtain a working hypothesis to explain the origin of living races
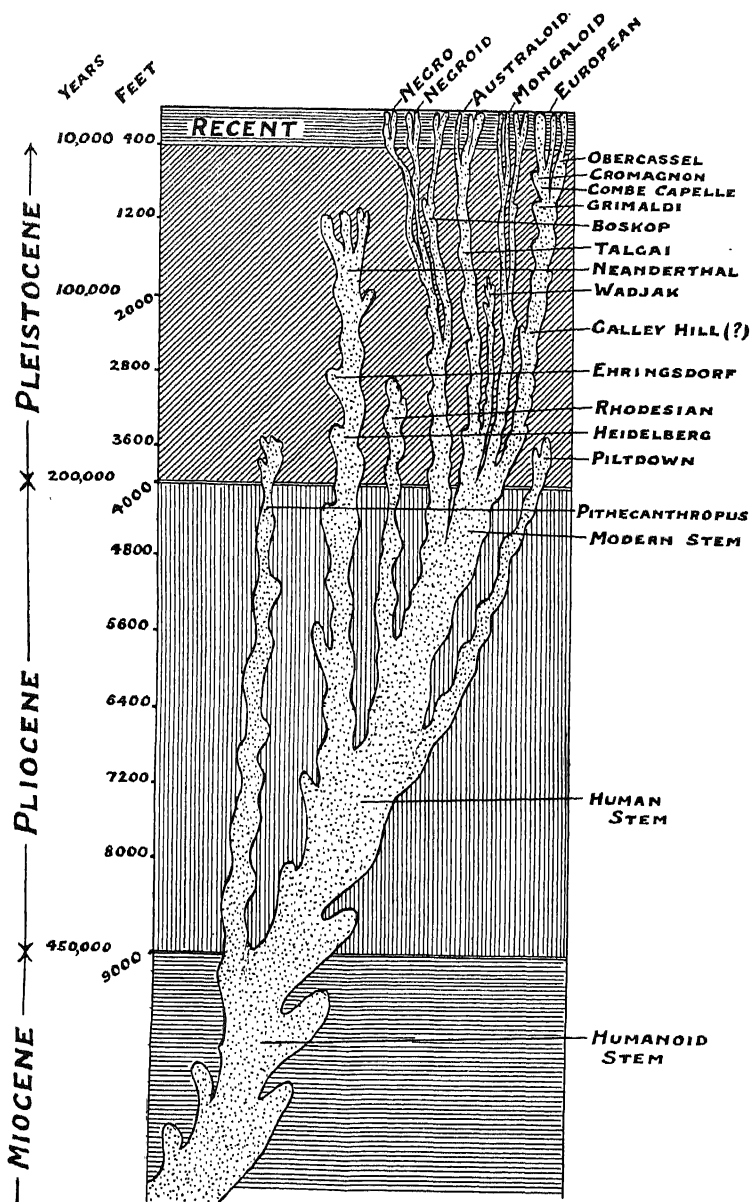
FIG. 263.—Genealogical tree of man's ancestry. The depths of deposits for each period are those given by Professor W. J. Sollas in 1900. It was then believed that these deposits might have accumulated at the rate of a foot per century, and on this basis the duration of the Pleistocene was estimated at four hundred thousand years, this being the estimate accepted in the first edition of this work. For reasons given in the text this estimate has now been reduced to half—namely two hundred thousand—and may have to be reduced still further.

—black, brown, yellow, and white. The genealogical tree, given in fig. 263, represents in a concrete form the anthropologists' working hypothesis. An inspection of this figure will show the reader that we think it necessary to carry the lineage of the various existing races of mankind back to the very beginning of the Pleistocene before they merge into a common type, the ancestral type of modern man. To bring a fair European, a representative Chinaman, and a full-blooded negro from a common ancestral stock implies great evolutionary activity during the last geological phase of the earth's history.

What was the duration of the Pleistocene period? In framing a genealogical tree and in estimating the rate at which evolution has worked on man's body the time element becomes all-important. In 1900 Professor W. J. Sollas [1] made a brave attempt to estimate the length of the Pleistocene. He found that the rivers of this period had carried down, and deposited in their estuaries and on the beds of adjoining seas, strata which, if superimposed, would give a total thickness of 4000 feet. He thought that a reasonable estimate for the rate of deposition, taking all circumstances into account, was a foot per century. On this basis a duration of four hundred thousand years was given to the Pleistocene period. It was this estimate which I used in 1914 when writing the first edition of this book, and it did not seem a bit too much to cover the evolution of living races of mankind from a common ancestral type.

This estimate, however, has to be modified, has to be reduced, when we trace man's history into the past by means of the trail he has left in caves and river terraces. By such means we have followed him, not only through the whole extent of the Pleistocene but far into the Pliocene. We found, as we followed him into the past, that the mode in which he fashioned his stone tools changed from time to time. The beginnings of our present mode of life are rooted in the Pliocene; between our way of living and that of Pliocene man lie a long

[1] See reference, p. 504.

succession of cultures or civilisations. As these were traced backwards, in chapter after chapter of this book, note was made of the probable duration of each, and our estimates, for convenience of reference, are summarised in fig. 264. On the cultural evidence the farthest stretch we can give the Pleistocene period is two hundred thousand years, and even this sum is conditional. If Mr Reid Moir is right in thinking that the true Chellean culture is found in the Cromer beds, then this estimate must be curtailed still further. In fixing the term at two hundred thousand years I have proceeded on the assumption that the great Mindel glaciation, the first of the Pleistocene period, the one which brought about the deposition of the deep chalky boulder clay, intervenes between the " early " Chellean culture found by Mr Reid Moir in the Cromer beds and the full-blown Chellean culture of the middle deposit of the 100-foot terrace—to which culture Galley Hill man has been assigned. If in this I have erred, if the Cromer beds are of true Chellean date, then we have to reduce the length of the Pleistocene to some one hundred and twenty or one hundred and thirty thousand years.

A student of man's evolution prefers to think, not in terms of years but of generations. If we take the larger estimate, two hundred thousand years, and suppose that reproduction went on at the rate of four generations to a century throughout this period, then man's body has been renewed some eight thousand times since the dawn of the Pleistocene. If we accept these data, and they are the most reliable at our disposal at the present time, then we have to infer that in the course of eight thousand reproductions modern races of mankind—black, brown, yellow, and white have been differentiated from a common ancestral stock. Evidence gleaned from Ancient Egypt and elsewhere tempted us to think that human types were enduring, but this wider survey leads to the belief that man's body and brain are plastic and that evolution has proceeded at a faster pace than was formerly thought possible.

Having thus made plain the time-scale on which we
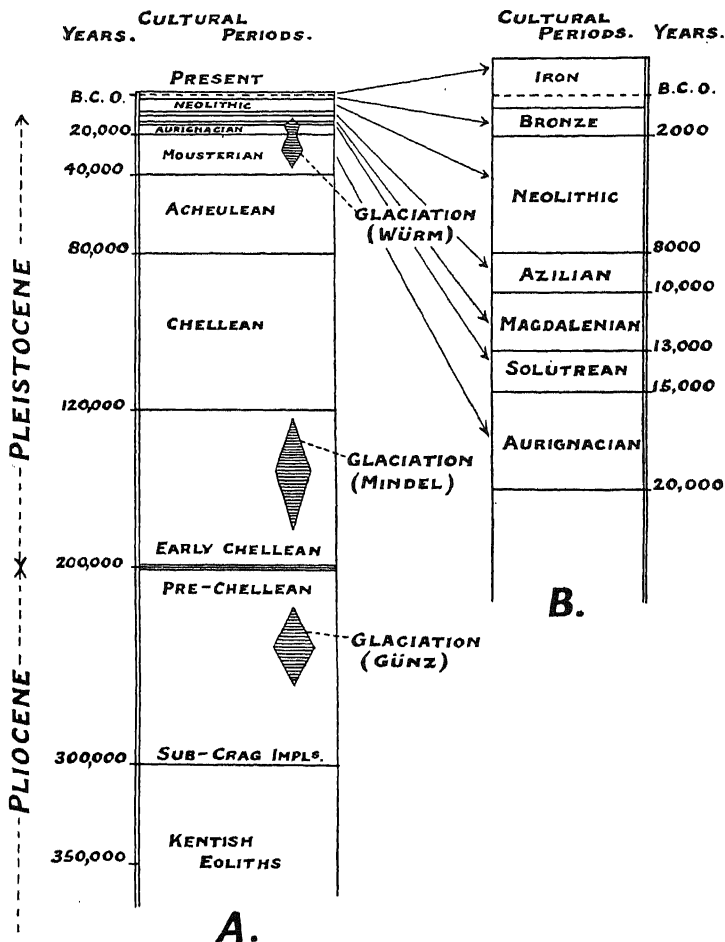
FIG. 264.—A. A diagrammatic representation of the cultural ages of the Pleistocene period.   The estimates of their duration are those adopted in this book.   They must be regarded as provisional.   Their relation to the first Pleistocene (Mindel) glaciation and to the last (Würm) is also indicated.   The cultural periods and glaciation of the latter half of the Pliocene are also represented.   B. A tenfold magnification of the later periods represented in A.

are proceeding, we return to the construction of man's family tree (fig. 263).   An inspection of this figure will

show the reader how little we know of the ancestry of living races. Of the predecessors of the Australian aborigine we know only the Talgai lad, but the evidence he affords is of the highest value. Of his place in the family tree there can be no doubt; he represents the stage reached by the most primitive of all modern types—the Australian aborigine—before the end of the Pleistocene period. How long before the end we cannot tell, but in placing him on the genealogical tree as the contemporary of Neanderthal man in Europe we do not strain the degree of his antiquity. At this early time we find one of the breeds of modern man differentiated. Further, we have seen that the ancestral Australian had to overcome great difficulties before he, his wife, and dog succeeded in reaching an isolated continent. We have seen, too, that modern Australian aborigines, although their teeth and jaws have undergone reduction, still breed true to type. The discovery at Talgai supports us in assigning a high antiquity to the modern type of man.

Of fossil representatives of the negro stem we have found only one example as yet—the big-brained Boskop man. He is by no means a pure negro type, but belongs to an ancient side branch now represented by the Bushman and Hottentot. We cannot give this extinct breed a higher antiquity than the end of the Pleistocene. Still the early appearance of such a highly differentiated human breed in South Africa bespeaks a great antiquity for man's evolution. The wide distribution of the negro type from the West Coast of Africa to the islands of the Pacific, and its division into numerous breeds, can only be explained by postulating a long period of evolution. The typical African negro, as we have seen (p. 375), must be regarded as the product of comparatively recent changes.

Of the fossil ancestors of the Mongolian stem we are not yet in a position to speak. It is highly probable that the discovery already mentioned (p. 459) may have brought some of them to light, but so far they have not been described. Such evidence as we possess leads us to

believe that the more distinctive features of Mongolian peoples are of recent origin, and that, as we trace this type into the past, it will be found to verge towards the ancestral stock from which European, negroid, and Australian types have sprung. The American Indian, whom we regard as a derivative of the Mongolian stem, was certainly evolved before the close of the Pleistocene period.

The Wadjak fossil type, voluminous as its brain was, may very well be placed near the basal Mongolian stem. It is certainly related to the Australian and Rhodesian types. In the genealogical tree Wadjak man has been given a place, provisionally, until we know more of him, between the Australian and Mongolian stems. As to the position which should be given to fossil men of the European type on our genealogical tree, there is no question. If we accept the geological evidence of the Chellean antiquity of Galley Hill man, and, in the face of other evidence, this becomes increasingly difficult, we have to believe that quite early in the Pleistocene period the European type, in all its details, was already in existence. The place of Galley Hill man is indicated in fig. 263. If we reject him, then the earliest traces of the European type are those found in the Grimaldi caves and the rock-shelters of Combe Capelle and Cromagnon. It has been said that the people represented by these remains—particularly those of the Grimaldi burials—show marked negroid traits. This matter has been discussed already (p. 100), and the conclusion drawn that they were not more negroid than many pure-bred representatives of the Mediterranean type now alive. The European has been evolved to the north of the Sahara, and the negro types to the south of it; the farther we trace them into the past, the more the white and black ancestral forms should come to resemble each other. The immediate ancestor of the European type has not yet been discovered. Nothing has been found in England or on the Continent which leads us to look upon our part of the world as the homeland of the type to which we belong.

The evolutionary cradle of the modern type lies elsewhere. Whatever may be the exact time of modern man's first arrival in Europe, his appearance there is that of an intruder.

As already said, the genealogical tree depicted in fig. 263 represents a working hypothesis, nothing more. When we try to represent in such a form the structural relationship between existing and extinct human races we again feel the necessity of postulating a great antiquity for man. This becomes evident when we seek to fit the stem or phylum of Neanderthal man into the genealogical tree of the human family. He was so different from modern man in every point of structure that, in order to account for his peculiarities, we have to represent his phylum as separating from that of the modern human type at an early date. In fig. 263 it will be seen that I have depicted the separation as having occurred before the middle of the Pliocene period. My reasons for selecting so early a date are : (1) that we must presume that man of the modern type was evolved by the end of the Pliocene period in order to account for the differentiation and distribution of the present races of mankind ; (2) that the discovery of the Heidelberg mandible indicates the existence of a Neanderthaloid type of man at the commencement of the Pleistocene period. I am thus presuming that before the middle of the Pliocene period there was in existence a type of man sufficiently high to serve as a common ancestor for the Neanderthal and modern species of man.

We have seen that, in mid-Pleistocene times, the brain of Neanderthal man, in point of size, was equal to that of any living race. His culture, that of the Mousterian age, was not a low one. We might suppose that the common Pliocene ancestor of these two species of man was of a low type, and that after their separation from the common stem each became gradually endowed with a large brain and acquired a separate form of culture. The more feasible explanation, however, is to suppose, not that a large brain was an independent

acquisition on the part of Neanderthal and the modern species of man, but that it was a common inheritance from their Pliocene ancestor. This seems to be the most reasonable explanation which is available at the present time—the one which presumes that Pliocene man had already reached a brain standard far beyond that of any simian type of animal.[1]

Can Rhodesian man be fitted comfortably within the human family tree which was outlined in 1914 ? I think he can ; the place given to him is shown in fig. 263. His geological age is uncertain, but in placing him near the beginning of the Pleistocene we do not strain such evidence as there is. From an evolutionary point of view he is a primitive, old type, such as we expect to meet with in deposits of the Pliocene period. Had we found merely his skull we should have placed him, without hesitation, as the common ancestor of the Neanderthal and modern types, for in his skull he combines the cranial features of the Australian aborigine and of the La Chapelle man. Some gorilline affinities are more apparent in him than in them. But his skeleton is altogether of the modern type ; in this respect he is less simian than the Neanderthal people. We therefore trace his origin to the basal stem of modern races, making him branch from this stem after the separation of the Neanderthal and Piltdown stems. Further, we represent the Rhodesian as a type which, like the Neanderthaloid, became extinct in the Pleistocene period. It does not seem possible to fit him in as a direct ancestor of any living race, and yet he foreshadows many features of the modern type, particularly of the Australian aborigine.

When we come to fix the place which must be assigned to Eoanthropus in the human phylum, we find further evidence in support of man's great antiquity. We have seen that in the opinion of the late Mr Charles Dawson the " minimum geological age of the fossil cannot be of

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[1] I have left this statement in the form I gave to it in 1914. As will be seen on p. 727, I have had to alter this opinion in the light of further evidence.

later date than the early part of the Pleistocene period."
He was also open to the conviction that it may have been
much older, and on the evidence given in a former
chapter we may reasonably presume that Eoanthropus
represents a Pliocene type of man.

The problem we have now to solve is this : Does
Eoanthropus represent the stage of evolution reached
by modern man about the commencement of the
Pleistocene period, or does the Piltdown type, like the
Neanderthal, represent a separate human species or
genus which became extinct and left no progeny ?   Sir A.
Smith Woodward's answer to this question is given in his
original communication to the Geological Society.[1]   " It
seems reasonable," he writes, " to interpret the Piltdown
skull as exhibiting a closer resemblance to the skulls
of the truly ancestral mid-Tertiary apes than any human
fossil skull hitherto found.   If this view be accepted,
the Piltdown type has become modified into the later
Mousterian (Neanderthal) type by a series of changes
similar to those passed through by the early apes, as
they evolved into the typical modern apes, and corre-
sponding with the stages in the development of the skull
in the existing ape individual.   It tends to support the
theory that Mousterian man was a degenerate offshoot of
early man, and probably became extinct ; while surviving
man may have arisen directly from the primitive source
of which the Piltdown skull provides the first discovered
evidence."   Sir A. Smith Woodward's answer to our
question, then, is that Eoanthropus does not necessarily
stand in the direct line which leads on to modern man,
but represents more closely than any human form yet
discovered the common ancestor from which both the
Neanderthal and modern types have been derived.

We have seen that Eoanthropus in size and shape of
brain, and in conformation of the skull, has a very high
degree of resemblance to modern man.   The characters
of the teeth and mandible, on the other hand, are more
simian than in any other form of man.   His forehead,

[1] *Quart. Journ. Geol. Soc.*, 1913, vol. lxix. p. 139.

although peculiar in some of its features, is modelled on modern lines. He had also some primitive traits in his skull. On the other hand, we find in the skull of Neanderthal man, and in Rhodesian man, numerous features which are also found in the skulls of anthropoid apes, particularly in the gorilla and chimpanzee. In many ways the Neanderthal skulls and brain casts are more simian, more primitive, than the corresponding Piltdown specimens. In the Neanderthal and Rhodesian types we find the canine teeth reduced and the chin region of the mandible assuming a non-simian conformation, as in the modern type of man. To explain such an irregular distribution of characters in those three types of man, we have to postulate such a generic tree as is shown in fig. 263. There the Pliocene human stem, from which we have derived the Neanderthal and modern types, is also seen to give origin to the Piltdown types.

The common Pliocene ancestor which gave origin to three such types could not be of a very low form. In Eoanthropus, as in Neanderthal man, the brain was equal in size to that of modern man. If we suppose that in an early part of the Pliocene period there was a form of man in which the brain had attained a human size, but in which the mandible, the teeth, and the skull still remained anthropoid in conformation, we have such a type as would serve as a common ancestor for Eoanthropus, modern man, and Neanderthal man. In the course of evolution the first named retained the ancestral form of mandible and teeth ; the last preserved the ancestral simian features of the skull. It will thus be seen that I look on Eoanthropus, as on Neanderthal man, as a representative of an extinct form of man.

We come, finally, to an important problem : What status are we to assign to Eoanthropus in the zoological scale of classification ? Sir A. Smith Woodward, in giving Eoanthropus a generic rank, seems to me to have altered the scale we have hitherto applied to the classification of human forms. All admit that Eoanthropus must be regarded as a form of man. A complete analysis of

the structural characters of the Piltdown type (so far as they are known to us), of the Neanderthal, of the Rhodesian, and of the modern types of man will show that all are of equal rank, and if we elevate one of them to a generic status we must do the same for the other three. Hitherto all modern races of men have been grouped under one species—*Homo sapiens*. The varieties of men which belong to the Neanderthal type are placed under the specific name of *Homo neanderthalensis (primigenius)*. If we apply the same standard of classification to the Piltdown type, then the name ought to be *Homo dawsoni*, not *Eoanthropus dawsoni*. For my part, I would welcome the innovation introduced by Sir A. Smith Woodward if it could be applied all round. Without doubt distinct varieties of Eoanthropus and of Neanderthal man, and of Rhodesian man, will be revealed by future discoveries—varieties which are sufficiently characterised to deserve specific names.

We now come to the position which must be assigned to the humanoid form found in Java by Dr Eugene Dubois. The thigh bone was shaped as in man, and we presume Pithecanthropus had a body fashioned much like that of modern man. In size of brain and shape of skull, however, this strange form occupies an intermediate position. The stratum in which the remains were found is assigned to a late Pliocene or early Pleistocene date. Clearly, Pithecanthropus represents an early stage in the evolution of the human phylum. The evidence already adduced indicates that certain forms of early man had already attained a high development in the Pliocene period. Therefore in fig. 263 the stem represented by Pithecanthropus is shown as separating from the ancestral phylum of man at a late part of the Miocene period. We can only explain the existence of so primitive a form of human being at the end of the Pliocene period by adopting an hypothesis of this kind.

It is only when we come to draft a genealogical tree, such as that shown in fig. 263, that we realise the true significance of those extinct human types. When we

look at the world of men as it exists now, we see that certain races are becoming dominant ; others are disappearing. The competition is world-wide and lies between varieties of the same species of man. In the world of fossil man the competition was different ; it was local, not universal ; it lay between human beings belonging to different species or genera, not varieties of the same species. Out of that welter of fossil forms only one type has survived—that which gives us the modern races of man. Further, we realise that the five human types so far discovered represent but a few fossil twigs of the great evolutionary human tree. We may hope to find many more branches.

Still more wonderful is it to find that these diverse types of the ancient world had their stone implements— their cultures. To retain purity of type, these ancient races must have lived apart and yet cultural fashions spread from one to another. And we can hardly suppose that the brain which was capable of even the most primitive form of culture was not also capable of speech. No wonder philologists find it difficult to trace the languages of modern man to a simple original tongue.

In framing a genealogical tree for man, or for any other species of animal, we must take into account the occurrence of " collateral evolution," a phenomenon known to geologists as the " law of uniform evolution." No one has had better opportunities of studying this law than Dr Henry F. Osborn, and no one has given to it a more explicit expression. " Some of the most universal laws as to the modes of evolution," he writes, " emerge from the comparative study of the horses, the proboscidians, and the rhinoceroses, from areas so widely separated geographically that there was no possibility of hybridising or of mingling of strains. For example, during a period, estimated at no less than five hundred thousand years, the horses of France, Switzerland, and North America evolve in these widely separated regions in a closely similar manner and develop closely similar characteristics in approximately a similar length of time. The same is

true of the widely separated lines of descendants from the mastodons, elephants, and rhinoceroses." [1] We must presume, to account for such things happening, that although the common ancestor of the horse did not possess the structural features which afterwards became manifest in its New World and Old World descendants, there must have been latent in this common ancestor a bias or tendency to produce such features.

The law of collateral or "uniform evolution" is certainly valid for the Order of animals to which man belongs. The larger monkeys of South America have brains, which in point of size and form are very similar to those possessed by monkeys of India and of Africa. But we cannot suppose that early in the Eocene period,[2] when the primates of the New World parted company from those of the Old, that the brain had passed far beyond its original simple form and small size. Since the separation of the Old and New World apes, their brains have gone on evolving, not exactly on the same lines, but on lines which have a remarkable degree of similarity. Such instances could be multiplied by those who have studied the anatomy of apes.

That the law of "uniform evolution" is also applicable to man there can be no doubt. Mention has already been made (p. 407) of certain structural changes which produce a sharp sill on the bony aperture of the nose. We found that this change was occurring in different living races— white, brown, and yellow, and also that it had taken place in some members of the Neanderthal species. We shall not find a sharp nasal sill in the common ancestral stock from which these races have descended, nevertheless a bias or tendency to produce such a change must have been latent in the common ancestor.

The discovery of the Talgai skull assures us that the teeth and jaws of the Australian aborigines have undergone reduction since Pleistocene times. That a similar

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[1] Henry Fairfield Osborn, *The Origin and Evolution of Life*, 1918, p. 263.

[2] See figs. 265, 266.

change has taken place in other widely separated races of mankind there can be no doubt. No one who has compared the teeth and jaws of the British people of to-day with those of their ancestors of a thousand years ago, or even of five hundred years ago, can help noting the retrogression which has taken place. It is tempting to suppose that such changes are the results of disuse—for cooking has relieved our jaws and teeth of hard work which was their natural burden in olden times. It does, at first sight, seem reasonable to expect that the discovery of fire and its application to the preparation of food, must have had much to do with the transformation of the massive jaws and gorilla-like face of early Pleistocene man into the Grecian countenance of classical times. A full examination of all the facts, however, has compelled me to reject this Lamarckian explanation.[1]

In a former passage (p. 721) I gave expression to the opinion that man's brain must have attained almost its full size in the Pliocene period because of the large brain possessed by two divergent stocks in the Pleistocene period. In Piltdown man the brain had reached a modern level; in Neanderthal man it had passed beyond this level. If the law of " uniform evolution " holds in this case, and I am now convinced that it does, then it is not necessary to suppose the early Pliocene stock, from which these types, as well as the Rhodesian and modern types, are descended, had a big brain; it is sufficient to suppose that the bias or tendency to a cerebral increase was latent in the common Pliocene ancestor, and that this tendency obtained its first structural manifestation during the evolution of his descendants.

Let me take one other example. The supra-orbital torus, which gives the foreheads of Rhodesian man and Neanderthal man their bestial aspect, is highly developed in the gorilla and chimpanzee. These two anthropoids are so closely related to man in a structural sense, that we

[1] See my Huxley lecture, " The Adaptational Machinery concerned in the Evolution of Man's Body," Supplement to *Nature*, 18th August 1923.

must suppose that they and man have a common ancestor, and that the anthropoids represent this common ancestor more closely than man does. We may presume, then, that the ancestral stock from which all human races have sprung, did possess this early birthright—a supra-orbital torus. Yet a distant cousin of the gorilla and chimpanzee —the orang—has lost the torus, or, it may be, it never had one. The torus has been replaced in all living races by eyebrow ridges of the modern type. This was also the case in Piltdown man. We presume, on reasonable grounds, that these frontal changes took place in the Piltdown ancestry and in the ancestry of modern man independently, after both had separated from the central human stem. Both were heirs to a common tendency. It is manifest that such considerations must be taken into account when we set out to build up man's family tree. The place of every member of that family must be determined, not on any single character, but on the structural aggregate.

This book is not a treatise on the evolution of man; it is merely a statement of the evidence of man's antiquity as seen through the eyes of an anatomist. The application of the law of "uniform evolution"—a very imperfect name to designate certain evolutionary occurrences—may lead my readers to suppose that I am prepared to agree with those that think some human races may have sprung from one kind of anthropoid, while others may have arisen from another kind. This I certainly do not think possible. The late Professor Klaatsch, for example, believed that the Mongolian stock had arisen from an anthropoid of the orang type, while the African negro had drawn his origin from the ancestral stock of the gorilla. Now there are certainly superficial points in which the Mongolian type resembles the Bornean anthropoid, but the true explanation of this resemblance is not that given by Professor Klaatsch. Cretins of all races are alike; they cease to be Europeans or Asiatics in appearance. Cretinism is the result of a defect of the thyroid gland—one of the glands of internal secretion. So potent is this gland in

fashioning the features that a cretinoid English child might well be taken, by a superficial observer, as brother to a Chinese cretin. It is also so when the pituitary gland becomes disordered; the subjects of acromegaly, no matter what their race may be, take on a superficial resemblance to each other. The glands of internal secretion are parts of the machinery of evolution, not only of man, but of apes.[1] The resemblances of the orang to the Mongolian type, which were noted by Professor Klaatsch, are due to a dominance—we may call it a thyroid dominance—in the action of their glands of internal secretion. The genetic relationships between species of men and species of animals has to be fixed on the aggregate of their structural characters, and when this principle is accepted there can be no doubt that human races, both living and extinct, are descendants of a common stock.

There is still one other law which we must glance at. We have seen that Sir A. Smith Woodward, in assessing the position of Eoanthropus, regarded the absence of a supra-orbital torus and other bony outgrowths of the skull as primitive marks. The inference that the absence of such structures is a primitive or ancestral stage is based on a misapprehension. Such structures are undeveloped in the skulls of apes as well as of man at birth, but this fact is far from proving they are primitive. We have had occasion several times to point out that characters which are transient in the foetal ape become permanent in man. Such are not primitive or ancient features : they are new. They reach an adult stage for the first time in man's body. It is during the foetal stages of life that new characters are introduced. Amongst such characters we must include the absence of bony outgrowths from the skull. The tendency of evolution in the human body is to retain, as far as is possible, foetal and infantile characters. The same tendency is seen at work in many forms of New and Old World monkeys. But in them such changes, although old, are in no sense primitive or bestial.

[1] See references on p. 385.

There is another route by which we approach the problem of man's antiquity. All who have made a study of the human body are agreed that we must seek for man's origin in an ape-like ancestor. If, therefore, we review the facts which bear on the evolution of the anthropoid apes, we may obtain collateral evidence bearing on the date at which the differentiation of the human body became possible. To save description, I have represented the present state of our knowledge of anthropoid evolution in the form of a genealogical tree (fig. 265). The stems of the three great anthropoids—the gorilla, chimpanzee, and orang—are seen to join together in the last part of the Miocene period. We have not many facts to guide us. We know of a late Pliocene anthropoid—Palæopithecus—which shows relationships to both chimpanzee and orang, but was probably not a direct ancestor of either. In 1915 Dr Guy E. Pilgrim found in Miocene and Pliocene deposits of India fossil jaws and teeth which represent six species of large anthropoids, all of them now extinct. In one of them—*Sivapithecus*—the molar teeth have certain human resemblances.[1] We know that the great anthropoids were already evolved in the Miocene period. Dryopithecus, of which six species are known, was alive in this period, and was about the size of the chimpanzee, but more primitive in features of tooth and jaw. We know, too, that the small anthropoids—the gibbons—were already in existence in the Miocene period. So far as our knowledge goes, the Miocene anthropoid apes offer us no form which can serve as a probable human ancestor. The small and large anthropoids were already differentiated, and we may presume that the same was the case as regards the ancestry of the human stock. Hence in fig. 265 the stems of the small anthropoids, of the great anthropoids, and of man are represented as already separated in the Miocene period. The evidence, slight as it is, justifies

[1] G. E. Pilgrim, " New Siwalik Primates and their Bearing on the Question of the Evolution of Man and the Anthropoidea," *Rec. Geol. Survey, India*, 1915, vol. xlv. p. 1.
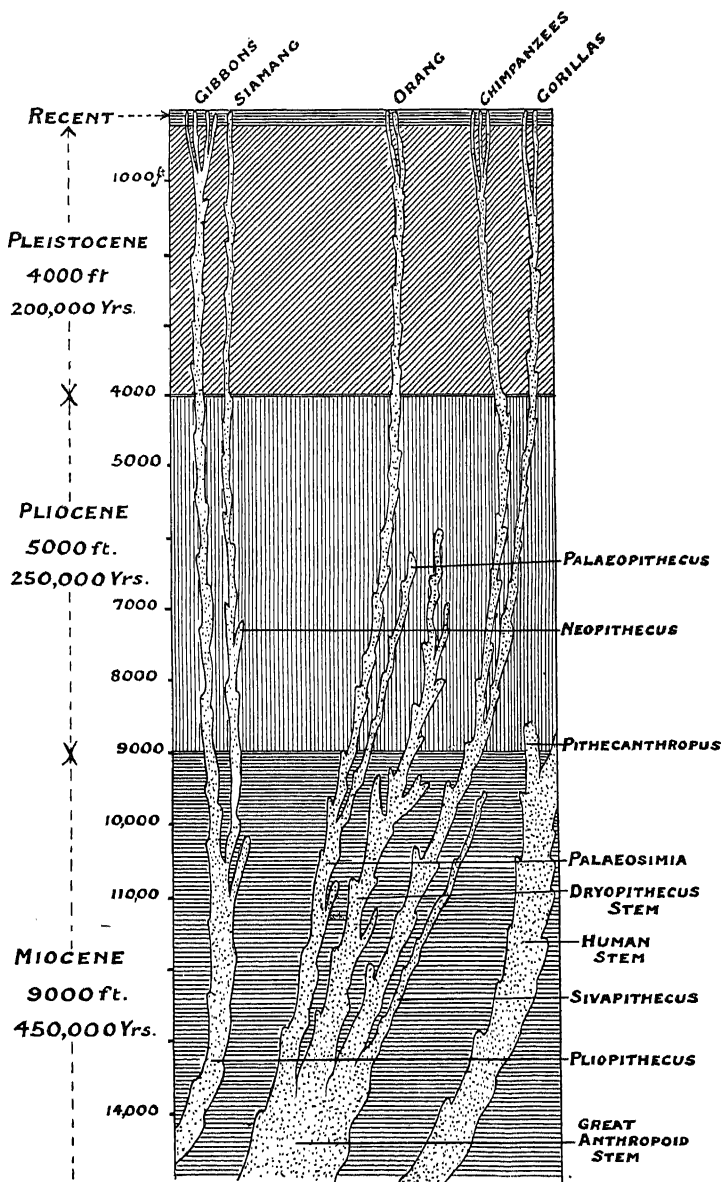
FIG. 265.—Genealogical tree, showing the lines of descent of the anthropoid apes.   See also legend for fig. 266.

us in presuming that the human and anthropoid lines of descent separated in pre-Miocene times.[1]

In fig. 266 the anthropoid and human genealogical trees have been combined. The tree represents a working hypothesis which may require alteration as new facts come to light. It is framed so as to account for the evolution and structural characters of the various forms of ape and man. The discovery of fossil remains of extinct forms gives us some guidance as to the probable date at which various types became evolved. In framing such a genealogical tree it is necessary—at least it seems so to me—to suppose that the separation of the human from the great anthropoid stem dates back to at least the latter part of the Oligocene period (fig. 266). If we mean by the antiquity of man the period which has elapsed since the human stem became differentiated from that which led on to the great anthropoid apes, then it is apparent from fig. 266 that the antiquity of man covers an immense period of time. On the scale of time represented in this scheme, a period of about one million years has elapsed since the separation of the human stem, provided, of course, that the hypothesis represented by our scheme is approximately right. Our tree probably errs in underestimating rather than overestimating the antiquity of the human stem.

When we speak of the antiquity of man, however, most of us have in mind not the date at which the human lineage separated from that of the great anthropoids, but the period at which the brain of man had reached a human level or standard. We may take the lower limits of the brain capacity in modern living races, say 1000 c.c., as a working standard. If it is arbitrary it is also convenient. If, then, we propose to estimate the antiquity of man from the appearance of human types with average brain capacities of 1000 c.c. or more, we must still regard man as an ancient form, with a past immeasurably longer than is usually believed. From

[1] For a fuller statement of the case, see *Reports of British Association*, 1912, p. 753 ("Modern Problems relating to the Antiquity of Man").
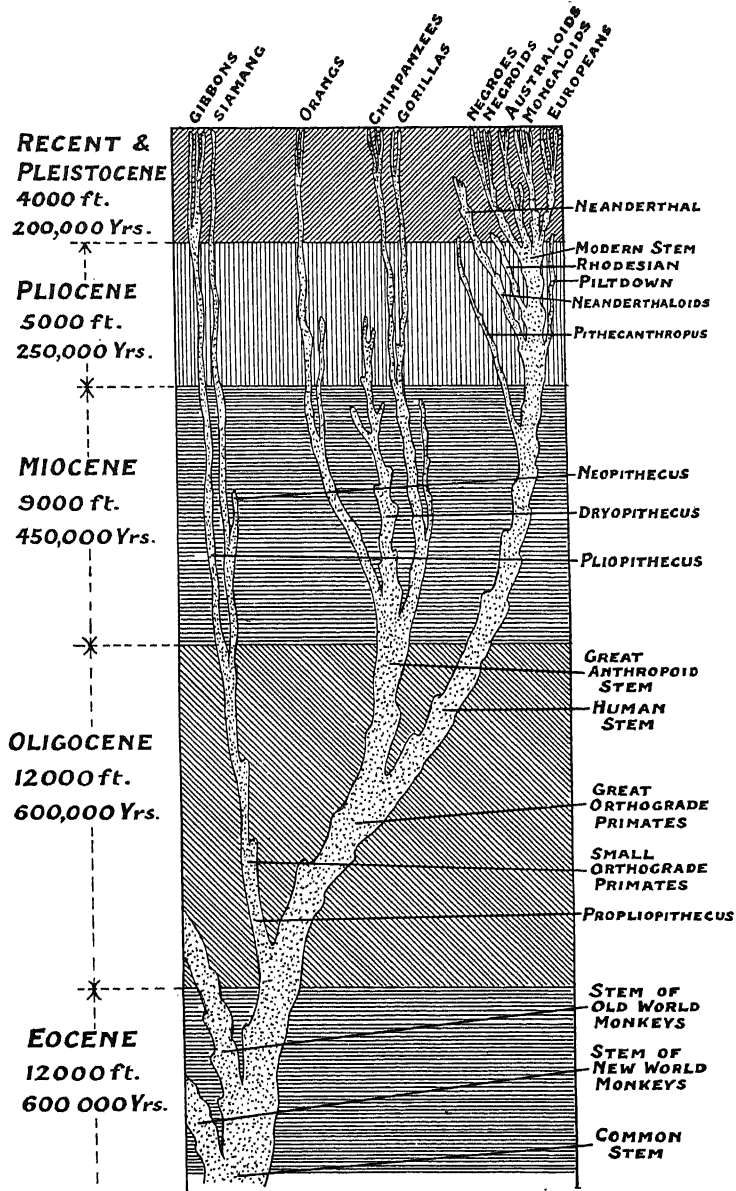
FIG. 266.—Genealogical tree, showing the ancestral stems and probable lines of descent of the higher primates. The geological periods, represented in this diagram by the relative depth of their deposits, are placed on the left. Under each period are given the estimated depth of its deposits and the time supposed to have been involved in their formation.

what we know, and from what we must infer, of the
ancestry of Eoanthropus, of Neanderthal man, and of
modern man, we have reasonable grounds for presuming
that man was approaching the human standard in size
of brain by the commencement of the Pliocene period.
From fig. 266 it will be seen that the Pleistocene and
Pliocene periods are estimated to cover a period of about
half a million years.   This period, on the grounds defined
above, represents the antiquity of man.

Perhaps the most important and the most convincing
source of evidence relating to man's antiquity is one
which has been kept unduly in the background throughout
this book.   We cannot have more certain evidence of
man's existence than the implements which he has shaped
and used.   We have seen how long it took to convince
the modern world that the palæoliths in the gravel
deposits of Western Europe were shaped by man's hand.
Now we marvel that anyone should have denied their
human origin.   Then came the discovery of Eolithic
implements in deposits of Pliocene date—at St Prest, on
the Kentish plateau, on the uplands of Belgium, under
the Crag deposits of East Anglia.   The human origin of
eoliths is still being called in question, but the more these
shaped flints of Pliocene date are investigated and dis-
cussed, the greater becomes the number of those who
regard them as the work of the hands and brain of
Pliocene man.   It is also maintained that flints, similar in
shape and chipping, have been discovered in deposits of
Miocene and even of Oligocene age.   If it be proved that
such are of human origin, then we must extend still
further the period covered by the antiquity of man.
There is not a single fact known to me which makes the
existence of a human form in the Miocene period an
impossibility.

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